FINISHES FOR ALUMINUM

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FINISHES ☆ FOR ☆ Aluminum

(1938)

ALUMINUM COMPANY OF AMERICA
PITTSBURGH, PENNSYLVANIA

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INTRODUCTION

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THIS BOOKLET has been prepared to assist the users of aluminum in solving their finishing problems. The procedures described have given satisfactory results in practical plant operations. Under different conditions, however, the directions may have to be modified. They are presented, therefore, as a guide for finishing procedures. They should be tested and perhaps modified before they are adopted for any given application.

Many attractive finishes may be applied to aluminum. To secure the best results, accurate knowledge of the characteristics of the finishes and the applications for which they are best suited is necessary. In an effort to indicate the field of usefulness of the various classes of finishes, the valuable features, the limitations and the methods of the application of each have been pointed out.

Aluminum Company of America maintains a technical staff whose services are available to users of aluminum for advice on all phases of finishing work.

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CHARACTERISTICS OF ALUMINUM

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ALUMINUM owes its wide and ever-growing use to certain well-known characteristics. Light weight, more than any other property, accounts for its amazingly rapid commercial development. Its pleasing color dulls but slightly with use, and is not greatly marred by oxidation. Its resistance to corrosion is sufficient for many applications with no additional protection. Other characteristics are its high electrical and thermal conductivity, its high reflectivity for light and thermal radiation.

Commercially pure aluminum is soft, ductile, and can be fabricated into complex shapes. Its physical properties may be altered (1) by cold working to increase tensile strength and hardness, (2) by alloying with small percentages of other elements to produce a wide range of properties, and (3) by heat treatment of certain of its alloys to add to their strength and hardness. The casting alloys can be cast in sand, dies or permanent molds. Wrought aluminum and its alloys are obtainable as plate and sheet; bar, rod, wire and rivets; seamless tubing and pipe; molding and structural shapes; screw-machine products; stampings, forgings and pressings; and impact extrusions.

For many purposes, standard sheet as it comes from the mill may be employed without any special finishing operation. Where appearance is not a factor or where the structure will be painted, "gray plate" may be used.

If the normal characteristics of plain aluminum do not provide the desired qualities for some specific application, there are available a great number of finishes to alter these properties. There are finishing processes that enhance the appearance of the aluminum surface, that increase its resistance to corrosion and abrasion, and that improve its reflectivity.

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MECHANICAL FINISHES

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ALUMINUM in its natural form has a pleasing appearance, but the metal surface may be improved for some applications by such mechanical processes as polishing, buffing, hammering, sandblasting, satin finishing or burnishing. These finishes may serve the purpose of blending the metal into an appropriate decorative scheme, or may simply form the foundation for other decorative or protective finishes.

As in the case of most processes, the quality of the finish will depend largely on the skill of the operator. However, the shape of the metal article and the nature of the alloy will also be determining factors. Hence, the actual plant practices prescribed here may have to be modified somewhat to accommodate any particular alloy or shape.

In order to avoid ambiguity the various operations of mechanical surface finishing are classified and defined according to the system used in general by the trade.

1. Grinding: Operations involving the use of a bonded abrasive wheel.

2. Polishing: Those operations involving the use of "set-up" wheels, belts or discs. Abrasive is attached to the periphery of the wheel or to the surface of the belt or disc, by means of glue. The polishing operations are further subdivided as follows:

Roughing: Coarse abrasives (60–100 mesh). No lubricant used.

Greasing or Oiling: Finer abrasives (120–400 mesh). Lubricant is used. The greasing operations are sometimes further divided and known as greasing, grease fining, grease finish and grease coloring, depending upon fineness of abrasive.

3. Buffing: The expression "cutting down" is sometimes used. In this procedure abrasive is applied to a sewed muslin wheel from a cake compounded of tripoli and other abrasives with a binder which supplies the lubricant.

4. Coloring: Sometimes termed "color buffing." This procedure differs from the above in that unstitched muslin wheels are used, and the abrasive is finer.

By means of these mechanical finishes, the surface is freed from irregularities or scratches produced during casting or fabrication, and, if desired, is brought to a high luster.

The mechanical equipment, both hand and automatic, for use on aluminum is of the same general type as that employed for other metals. In its selection, certain fundamentals should be observed. Equipment must be of ample capacity, and sturdily constructed to withstand heavy and continuous service. It should be set up on a solid foundation to eliminate vibration. Polishing wheels must run true and must be properly balanced. The composition and construction of these wheels and their speed are variables that are discussed later.

GRINDING

Large castings, which cannot be held against an ordinary wheel, demand special methods of handling to prepare them for final finishing procedures. Portable, rotary air grinders, developing 5400 r.p.m., and set up with cup-grinding wheels, are used for breaking down the "as-cast" surfaces. These rough grinding operations are necessary for preparing castings for sandblasting. Surface irregularities, if not removed in the initial treatment, become more prominent and more expensive to remove in later operations. For flat surfaces, and particularly for removing any appreciable amount of metal, phenolic-resin-bonded, silicon-carbide, cup-grinding wheels (6″ x $2\frac{3}{16}$″ x $\frac{1}{8}$″) with No. 24 to No. 50 grit are satisfactory.

Rough grinding is preferably done dry but tallow or lard oil, if applied with care, may be used when necessary. In cases where oil and grease are present in excess, they can be removed by preheating the casting to a temperature of 400°F. to 600°F. for approximately one-half hour.*

Detrimental depressions in the surface of a casting, resulting from sand holes and porosity, may require welding. The welded areas can be blended into the surface of the casting by means of a cup wheel or by means of a disc sander as described under "Roughing." Welding may cause discoloration in castings that are oxide coated by the Alumilite** process. This can be minimized by heating the casting to between 900°F. and 960°F. for 1 hour to 5 hours prior to sandblasting and finishing by the Alumilite process.

POLISHING

Roughing: The coarse polishing operation, known as roughing, is employed as a preliminary step in polishing very uneven or deeply scratched surfaces. Sand castings always receive this treatment. Portable equipment such as described on page 10, under "Grinding," is sometimes used on large castings. Instead of a cup-grinding wheel, flexible carborundum paper discs are used. These discs are about 9 inches in diameter and vary in coarseness of abrasive, 24 mesh to 80 mesh, depending upon the nature of the work.

Die castings and fabricated articles do not necessarily require the roughing operation unless their surfaces are unusually rough or marked.

For roughing, a wheel made of pieces of muslin or canvas glued or cemented together is needed. Other materials, such as wood faced with leather, sheepskin, felt or flannel can be used. In general, the weight and grade of the material and the method of joining the pieces influence the wheel's flexibility which is important in the polishing of curved surfaces.

*This method cannot be applied in the case of heat-treated castings because of the adverse effect on their mechanical properties and dimensions.
**Patented process for producing oxide finishes.

Regardless of material chosen for the wheel, the facing procedure is the same. A layer of glue is applied, in which No. 60 to No. 100 emery or fused aluminum oxide abrasive is embedded. Careful application of glue and abrasive will prevent many polishing troubles. Both the composition and application of the glue should be determined by up-to-date recommendations of abrasive grain suppliers and manufacturers.

The diameter of the wheel may range from 6 inches to 20 inches, and its thickness from 1½ inches to 3½ inches, depending on the area of the work to be finished. The wheel should have a peripheral speed of about 6000 feet per minute. Slower speeds tend to tear the abrasive out of the glue while higher speeds cause excessive heating which may break down the glue. A lubricant such as tallow or a mixture of tallow and lard oil may be used on the wheel to reduce the heating. This must be done with care, however, in order to avoid driving the lubricant into the pores of castings and spotting the surface by seepage in some later finishing operation.

Greasing: This finishing treatment, sometimes known as oiling, is a refinement of the roughing procedure, and similar to it except that a lubricant is always used on the wheel. Sand castings are invariably given this greasing treatment after being roughed. Die castings are given it as the first polishing operation. Fabricated articles that have been roughed on a rag or canvas wheel require it as a preliminary operation before buffing. For the greasing process, a felt wheel, or sometimes a sheepskin wheel, faced with No. 100 to No. 220 emery is used. This is a softer wheel and a finer abrasive than is required for roughing. The felt wheel has the advantage of uniform density and contains no sewed or cemented seams. Selection of the proper grade of felt must be made since several degrees of hardness are available. For example, a soft, pliable grade is desirable for finishing irregular surfaces. Wheel speeds and dimensions are much the same as those used for roughing, and are based on similar con-

siderations. The lubricant is important as a means of reducing the danger of burning, and may be tallow, oil, beeswax or tallow compositions. A single wheel greasing operation is generally sufficient. A higher polish may be obtained, however, by the use of a wheel faced with No. 100 emery followed by treatment with a second wheel faced with No. 220 emery.

BUFFING

Buffing is the next finishing operation used on an aluminum surface when the objective is to bring out the high luster of the metal It differs from roughing and greasing in that the abrasive is embedded in a grease binder and rubbed on instead of being glued to the face of the wheel. The selection and proper application of the most suitable abrasive for the work is important.

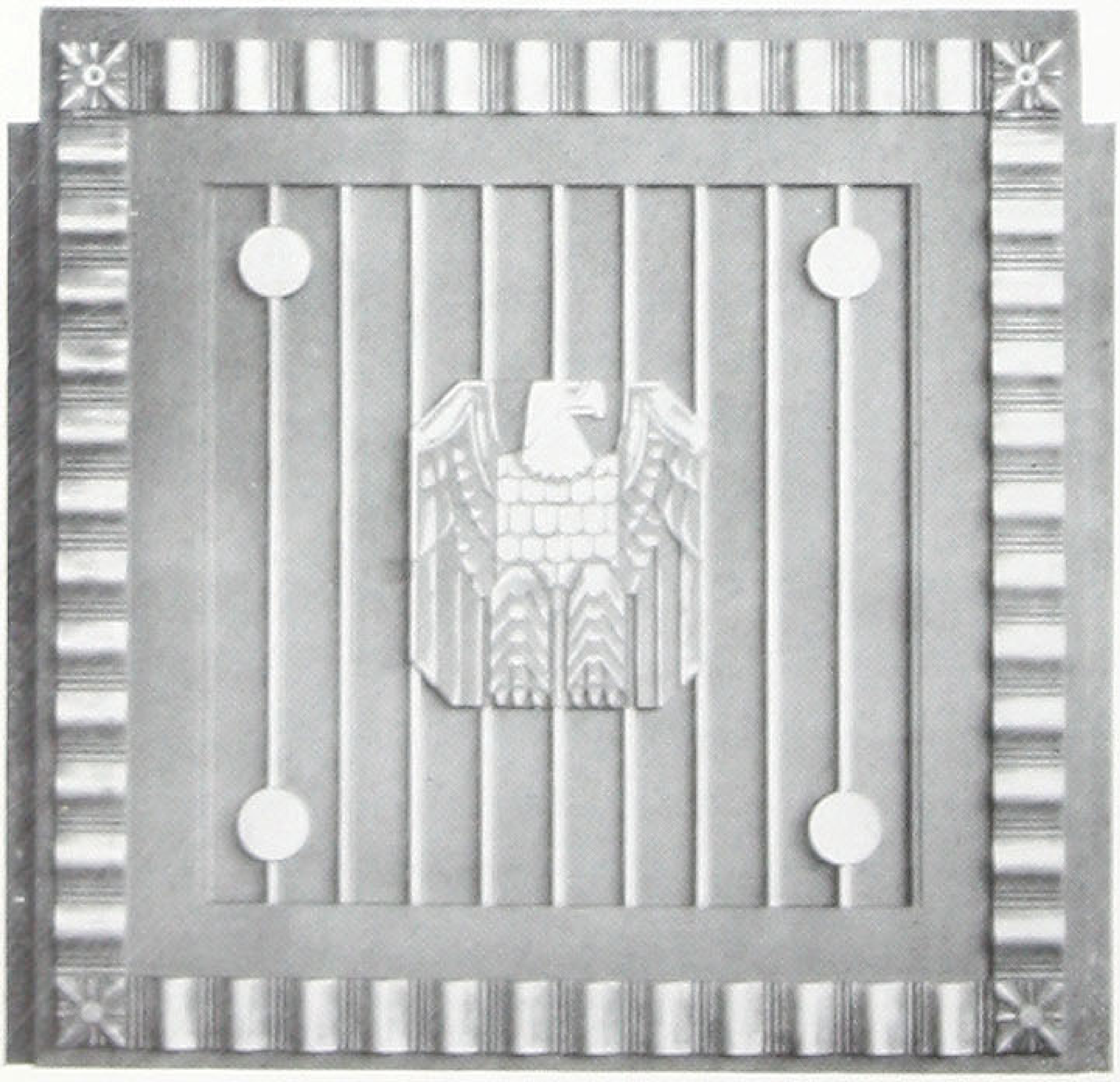
Tripoli powder is by far the most common of the buffing agents. Chemically it is high in silica and its value as an abrasive lies chiefly in its physical structure. The grains are soft and spongy, and free from sharp crystalline cutting edges. They crush down in buffing to present fresh polishing surfaces. Tripoli powder is available in several degrees of fineness. Fine-grained material is preferred in that it produces a brighter finish. Purity and uniformity of grain size are also essential to secure satisfactory work.

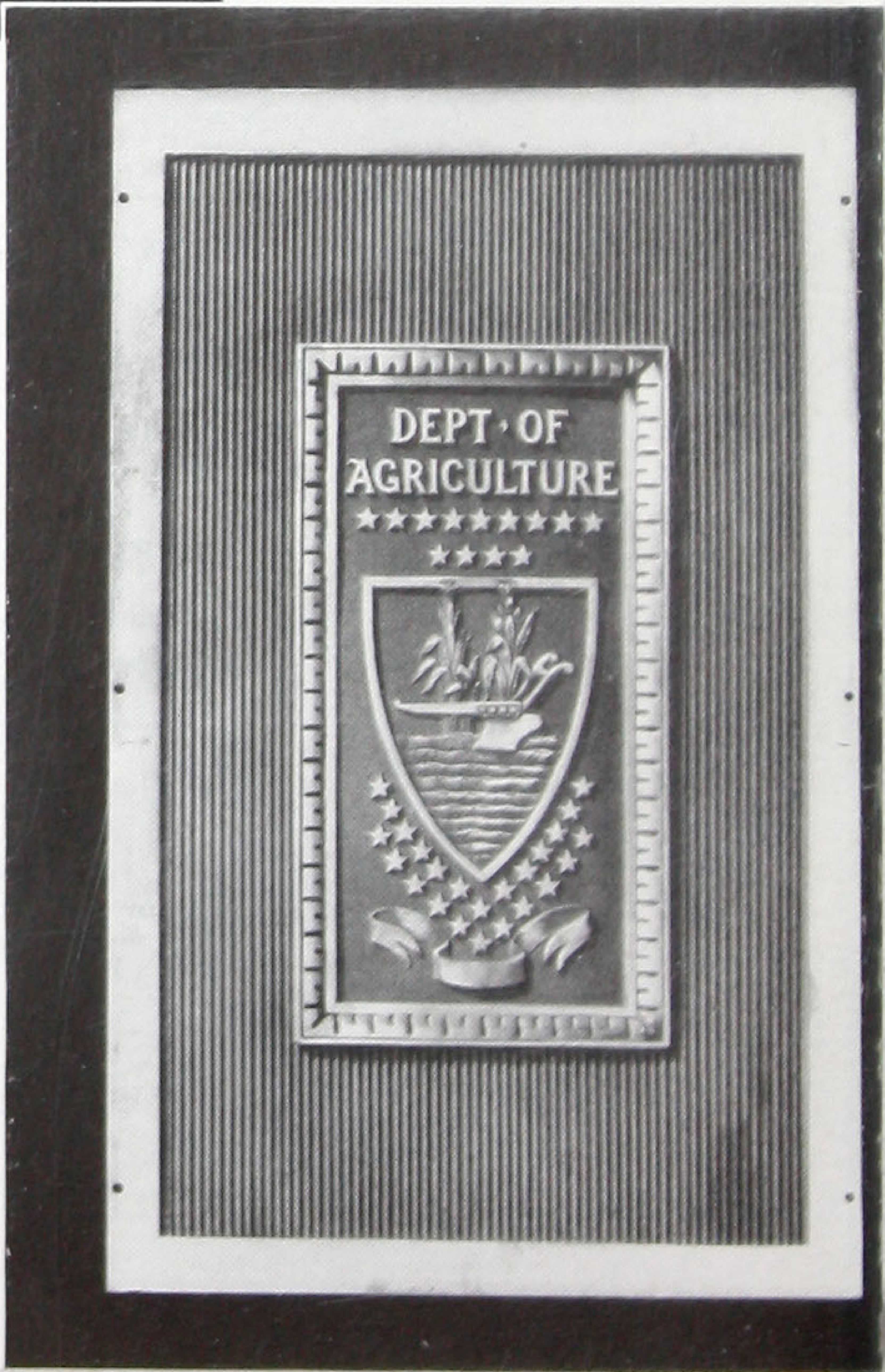
The abrasive powder is mixed with a grease base and molded in a cake. Cakes in which tripoli powders of various degrees of fineness are incorporated may be purchased from suppliers. The abrasive cake is pushed against the wheel as it revolves. The heat generated softens the binder and the abrasive becomes attached to the wheel. This procedure must be repeated frequently to preserve the cutting action.

The wheels are run at a higher speed than that used in the earlier finishing operations in order to hold the edges of the buffing wheel close to the work. It is possible to increase the speed of the wheel because of the decrease in heating effects. Buffing wheels should have a peripheral speed of 7000 to 7500 feet per minute.

Jewelry made of aluminum may be finished by buffing, ball burnishing or hammering.

Sand-cast aluminum spandrels finished by sandblasting, deplating, and oxidized high lighting.





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Difficulties Encountered in Buffing: The difficulties frequently encountered in buffing are the formation of pits, surface roughness, and buffing clouds. These difficulties may be corrected by attention to one or more of the following factors:

Hardness of buff
Buffing compound
Peripheral speed
Pressure against buff

The harder the buff the better the cutting qualities which will produce a smooth surface. However, there is greater tendency to form pits or cloudy or streaked areas. Hardness in a buff results from:

Material of high thread count
Close spirals in stitching and short stitches
Few or no spacers between discs, and few or no spacers between sections
High peripheral speed

The softest buffs, such as used in coloring, are made from material having low thread count. The only stitching is around the arbor hole—just enough to hold the sections together. As many as four spacers may be used between discs, and between sections. The spacers referred to are generally 3-inch to 4-inch discs, and may be of paper or cut from worn buffs.

Where pitting and clouding difficulties exist, attention should be directed toward softening of the buff. The type of buff, in which all the cloth is exposed to the cutting surface on a bias, provides a soft buff.

The buffing compound should be selected for the particular job on the basis of test. Abrasives used in buffing compounds vary considerably in hardness and cutting properties. The grease binders are also varied, depending upon melting point desired. With decrease in the melting point of the binder there is less danger of pitting and overheating, and a decrease in luster, but the cutting quality and tendency toward cloudiness are increased. A greater amount of lubricant is needed for buffing aluminum than for harder metals.

TYPICAL POLISHING PROCEDURES

Article	Operation	Wheel	Composition
Sheet Cooking Utensils	1. Buffing 2. Coloring	Sewed muslin buff Open muslin buff	Tripoli Soft silica
Screw-Machine Products	1. Greasing 2. Buffing 3. Coloring	Felt or sheepskin Sewed muslin buff Open muslin buff	No. 180 or flour emery Tripoli Soft silica
Die Castings	1. Greasing* 2. Greasing* 3. Buffing 4. Coloring	Glued rag wheel Felt wheel Sewed muslin buff Open muslin buff	No. 100 emery No. 150 emery Tripoli Soft silica
Sand Castings	1. Roughing 2. Greasing 3. Buffing 4. Coloring	Glued rag wheel Glued rag wheel Sewed muslin buff Open muslin buff	No. 70 to No. 100 emery No. 100 to No. 220 emery Tripoli Lime

*May omit one or both.

High peripheral speeds increase effective buff hardness and improve cutting qualities, but increase the tendency for pitting and formation of cloudy areas.

High pressure against the buff increases the cutting rate, but also increases the tendency for pitting and cloud formation. In general, pressures used in polishing or buffing aluminum or its alloys are less than those used for harder metals.

All of these factors are important, but in addition thereto, the operating technique gained through experience, observation and instruction is an essential requirement.

COLORING

The final operation of the finishing procedure is known as coloring. Actually, the metal surface does not change noticeably in color, but takes on a characteristic luster and high gloss. Preparation by cleaning in benzine and drying in sawdust precedes coloring. It is frequently found desirable in preparing a surface for finishing by the Alumilite process to give the article a light caustic etch between the buffing and coloring operations. The chemical treatment removes embedded abrasive which, if allowed to remain, tends to produce surface discoloration during electrolytic oxidation. The coloring is done on open muslin or flannel wheels, similar to the buffers. They may have spacers between them to make them softer, and a peripheral speed of 7500 to 8000 feet per minute is used. The abrasive is soft silica mixed with a grease base.

FINISHING SEQUENCES

This discussion of finishing materials and procedures gives general directions for surfacing aluminum. To finish any particular aluminum article, however, the specific details of the process must be worked out experimentally, bringing into consideration the nature of the metal, the surface and the desired finish. The table on page 16 indicates some of the variations in method required to produce the same kind of finish on different forms of aluminum.

HIGH-LIGHTED FINISH

Very attractive effects may be obtained on aluminum articles by the process known as high lighting, which gives the raised portions of the surface one type of finish, while the recesses receive another. Such decorative treatment has been widely employed on refrigerator evaporator doors. The background is sandblasted and the high-lighted areas buffed by the following sequence of operations.

1. Raised areas are protected by some covering such as adhesive tape, a rubber mask or heavy paint, while the background is sandblasted. (See "Sandblasting," page 23.)

2. The article is given a caustic treatment to prepare the sandblasted background for later finishing by the Alumilite process.

3. The background is protected by taping or painting while the high lights are buffed.

4. An Alumilite finish is applied as a final operation to protect permanently the entire surface.

The technique for high lighting castings has been worked out in considerable detail for architectural applications. Generally the work is done by means of rotating abrasive wheels for irregular castings, and for flat articles a belt sander is used.

Wheels used are the standard 6-inch to 12-inch sewed muslin discs, glued together to give the required thickness and faced with No. 60 to No. 120 emery. The normal precautions in setting up such a wheel should be observed, and the glue should be allowed to dry thoroughly before use. Each new wheel should be broken down with a file to reduce the heavy cutting action of the fresh emery. Polishing wheels of this type are employed in connection with horizontal air grinders operated at from 3400 r.p.m. to 4400 r.p.m. If larger wheels are used, the speed may be reduced to maintain the same peripheral speed. Wheels with No. 120 emery are used with tallow. Wheels with No. 180 emery are commonly employed with a greaseless polishing medium. If more lustrous finishes are desired, the surfaces may be buffed with a

muslin or felt wheel and a compound such as tripoli. A buffed surface may be given a still higher luster by coloring.

Where plain flat surfaces must be high lighted absolutely smooth and free from ripples, the belt sander is used. Cloth belts of Nos. 80, 120, 140 and 180 emery are employed in the order given, depending on the texture desired. No. "O" tallow and a small amount of machine oil are required as a cutting lubricant, or a thin paste of paraffin and turpentine also makes a satisfactory compound. A belt-sanded surface may also be buffed with muslin wheels and tripoli if a lustrous finish is desired.

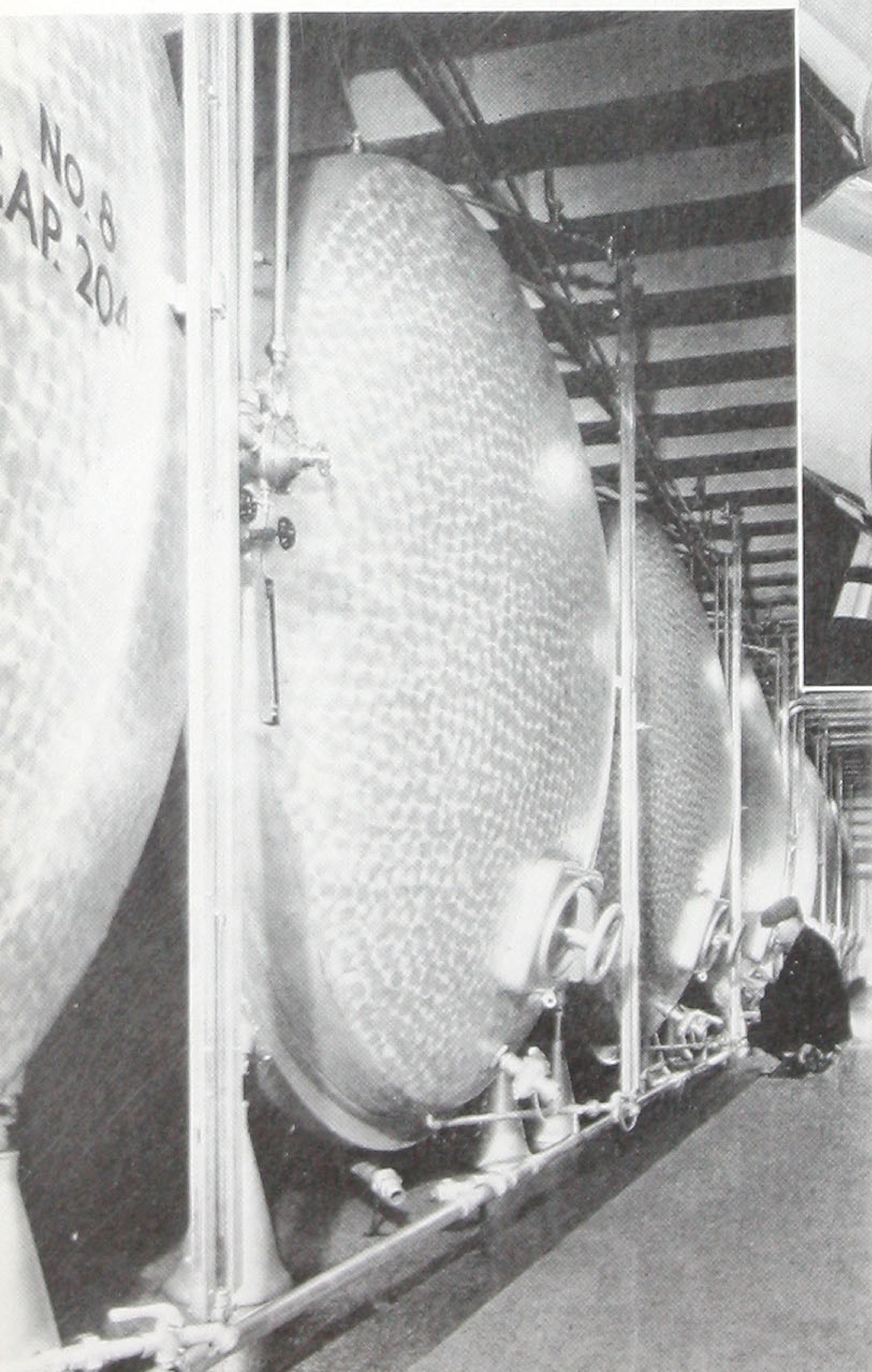
SCRATCHBRUSH FINISH

A coarse-lined finish may be obtained by the application of a rotating wire brush to the aluminum surface. Fineness of the finish may be regulated by the size of wires used in the brush. Wire wheels 10 inches in diameter, made up of wires 0.015 inch in diameter, revolving about 2000 r.p.m., are generally satisfactory. Wires may be composed of brass, stainless steel, nickel or German silver.

Dirt and grease must first be removed from the aluminum surface by rubbing it with air-slacked lime. Then it is held lightly against the edge of the revolving wire brush until the desired roughening is attained. On castings, the scratchbrush finish is applied, preferably after a fine sandblast, but if the surface is exceptionally rough, it may be necessary to use the medium sand. The method of application for castings is identical with the procedure for other forms of aluminum with the exception of wheel speed, which is reduced to 450 r.p.m. to 600 r.p.m. for best results. Higher wheel speeds result in excessive tearing of the metal surface and subsequent lack of uniformity in the final finish. As the wheels are used, they gradually accumulate oxide and metallic aluminum particles and must be cleaned frequently. This can be done by using a pumice stone or soft brick. As the wheel wears, the wires also become bent and dull, necessitating frequent reversal of the direction of rotation.

A combination of hammering and hand work produces the rich, artistic finish of these aluminum decorative pieces.

Aluminum cooking utensils receive their brilliant luster by polishing. The process includes several operations, all of which are described in this chapter.



Circular wire brushing is a convenient means of relieving the monotony of large plain areas. This mechanical finish is applied here to the ends of storage tanks.

SATIN FINISH

Satin finish is a modification of the scratchbrush finish obtained by treatment of the metal with a finer wire-brush wheel or by abrasives. It imparts a soft, smooth sheen with lower reflectivity than a highly polished surface. The soft effect results from the tiny parallel lines scratched on the metal. Various effects may be obtained by changing the angle of contact of the surface with the wire brush. Wires of 0.002 inch to 0.005 inch in diameter are most often used; the finer the wire, the finer the texture of the finish. Some difficulty may be experienced in applying this finish uniformly to large areas.

For some surfaces, like the inside of cooking utensils, the same kind of satin finish may be obtained without the use of the wire brush. The object may be rotated in a chuck while holding an oily abrasive cloth firmly against the surface as it revolves. A further rubbing with steel wool dipped in oil and emery powder and a final cleaning with a rag while the article is still revolving gives a bright silvery finish. Steel wool lubricated with soapy water or greaseless polishing compounds can also be used to satin finish aluminum very satisfactorily.

To produce a satin finish on castings, their surfaces must first be polished as described under high lighting. After the use of the No. 180 emery, the surfaces are buffed with muslin or felt wheels with greaseless polishing compound. Various grades of greaseless compounds give a coarser or finer finish, depending upon the grain size of the abrasive contained in the compounds. A very fine satin finish may be obtained by using a rotary fiber brush or rubbing by hand with a paste made of pumice and oil.

If the surface of the casting, after the basic polishing operations with No. 120 and No. 180 emery, is buffed with a muslin or felt wheel and emery cake, a satisfactory base for a wire-brush satin finish is obtained. On large flat surfaces, a fine, mild sandblast before wire brushing is quite essential to maintain a uniform satin appearance. Before using the wire brush, the prepared surface must be thoroughly cleaned of grease and dirt with a

suitable solvent or by means of preheating for ½ hour at 400° F. to 600° F.*

A 6-inch diameter wire brush made of nickel, stainless steel or German silver wires 0.004 inch to 0.010 inch in diameter and operated at 450 r.p.m. to 600 r.p.m. is used to give the desired satin appearance. As with the regular wire-brush finish, these wheels should be cleaned frequently.

A finish closely approximating the true satin finish can be obtained with a belt sander when surface conditions permit the use of this equipment. By using belts of Nos. 80, 120, 180 and 240 emery and a belt speed of from 2400 to 3000 feet per minute, a finely cut surface is produced. By hand finishing with pumice or steel wool and kerosene, a still finer finish is obtained.

HAMMERED FINISH

Hand-hammered aluminum has a finish closely resembling that of hand-wrought silver. It finds its best applications in novelties and giftware. It can also be given an appearance similar to that of antique hand-hammered metals. Such effects may be obtained on aluminum by several methods, a common one being to heat the material to be so finished in a smoky coal fire and perform the forging operations while the work is covered with a fine layer of soot. Part of the black deposit is hammered into the surface, giving an effect suggestive of wrought iron. Often the raised portions are high lighted by going over them with emery cloth or steel wool. Sometimes the article is held in a smoky flame and the excess soot removed by rubbing with fine steel wool as a finishing operation.

FLUTING

Fluting consists of rolling parallel lines into the surface of the sheet. This makes an inexpensive and attractive surface for

*This method cannot be applied in the case of heat-treated castings, because of the adverse effect on their mechanical properties and dimensions.

some purposes, but it can only be applied at the mill. It is effective in hiding the structural markings of metal that is subsequently to be given an Alumilite finish.

SANDBLASTING

Sandblasting is a rapid and inexpensive method for finishing aluminum. It gives a uniform matte surface, appropriate for some articles. But the plain, sandblasted surface, because of its roughness, will in time collect and retain dirt. Therefore, in some cases, it may be desirable to protect the sandblasted surface by a lacquer or a clear varnish coating, making it easy to maintain the finish by washing. Likewise, the sandblasted surface may be given an Alumilite finish, if desired.

A wide range of blasting materials is available and lends different color effects to the aluminum surface. Washed silica sand is probably the most commonly used abrasive, although in some cases steel shot, pulverized silicon, carborundum sand or other materials may be employed. Silica sand and steel shot impart a light gray color; pulverized silicon, a light blue cast; and carborundum sand, a dark gray. Because metal abrasives leave particles on the aluminum surface that form discoloring products of oxidation, they are not favored. The use of four grades of silica sand is described in detail below.

The coarse sandblast finish is obtained by using crushed silica rock of 6 mesh to 20 mesh. Since it breaks down slowly during the blasting, new sand should be added to keep it at the required grit to insure uniform finish. The sand is used with a $\frac{3}{8}''$ x 3″ or $\frac{1}{2}''$ x 3″ chill-cast-iron nozzle, with air pressures of from 30 pounds to 90 pounds per square inch. For small, light work, the $\frac{3}{8}$-inch nozzle and 30 pounds to 90 pounds air pressure are employed, while for large, heavy work the $\frac{1}{2}$-inch nozzle and 50 pounds to 90 pounds air pressure are most satisfactory. The lower pressures decrease to some extent the roughness produced by the sand. Higher pressures than those indicated should not be used, because of the excessive warping produced. During the blasting, the nozzle is held at from 12 inches to 20 inches from

the work and at an angle of 60° to 90° with the surface. The distance from nozzle to work depends upon whether the article has an irregular or plain surface, the irregular surface requiring a shorter distance. Motion of the nozzle in blasting should be in parallel lines extending the full length of the work. The sandblast nozzle should be discarded when the size of the nozzle hole has increased to such an extent as to change the nature of the blasted surface.

The grade of sand used for the medium sandblast finish is washed silica sand of from 40 mesh to 80 mesh. This sand likewise breaks down with use and more must be added from time to time to replace that which is lost through dusting, and to keep the cutting action uniform. The nozzles, which may be ¼″ x 5″, ⅜″ x 3″, or ½″ x 3″, are generally operated at air pressures of 30 pounds to 90 pounds per square inch, depending on the type of work. Air pressures lower than 30 pounds per square inch may be used in some cases, but with increased blasting time. Higher pressures roughen the work excessively and cause unnecessary warping. For this type of blast, the nozzle is held approximately 8 inches to 14 inches from the surface; otherwise manipulation is the same as for coarse sandblasting.

For a fine sandblast finish, a silica sand having a fineness from 100 mesh to 200 mesh may be used. In order to provide a uniform flow, it has been found necessary to add to each 400 pounds of fine sand, 100 pounds of somewhat coarser sand. If this is not done, the fine sand has a tendency to clog in the nozzle and prevent uniform flow. The addition of this coarser material has no detrimental effect. The size of nozzle used with this sand is either ¼″ x 5″ or ⅜″ x 3″ at an air pressure of 30 pounds to 75 pounds per square inch. Other considerations are the same as for medium sandblast.

A sandblast finish comparable to that obtained with the fine sand may also be obtained with flint shot sand that has been partially broken down with use. A ½″ x 3″ cast-iron nozzle is most satisfactory, operated at 30 pounds to 80 pounds per square inch air pressure.

In applying sandblast finishes to sheet, it is sometimes necessary to use lower pressures to avoid warping of the metal. For certain work a very fine sandblast has proved desirable. In such cases, the blasting material is 200 mesh or finer. The nozzle is ½″ x 3″ and the nozzle-to-work distance is 8 inches to 12 inches. The air pressure is approximately 45 pounds per square inch.

If the sandblasted surface is to serve as a foundation for an Alumilite finish and a light color is desired, it should be immersed in a caustic solution (see "Frosted Finish," page 29); otherwise, the surface will have a non-uniform, dark-gray appearance.

The sandblasting of aluminum requires much the same equipment as that used for other metals. There must be a sandblast chamber, which is a closed room fitted with an exhaust system and a hose for the blast. The room may also be equipped with some method of conveying the work past the operator or the automatic blasting machinery. The abrasive can be introduced into the column of compressed air by gravity, suction or by mixing directly under pressure. The method chosen for getting the abrasive to the metal depends on the purpose for which the metal is being prepared. The workman should be protected against dust by suitable appliances.

There are four principal factors which determine the texture of the sandblasted surface and it is only through control of these factors that uniformity may be obtained. These factors are: (1) air pressure, (2) rate of introducing sand, of which nozzle size is a factor, (3) grade of sand or abrasive, and (4) nozzle-to-work distance and angle. Once these conditions are selected, they should be adhered to carefully so that a uniform finish is secured.

TUMBLING AND BURNISHING

Burnishing has no cutting action; it removes no metal, but instead applies pressure to the projecting points or particles and flattens or spreads them out. Ball burnishing produces a finish entirely satisfactory for many articles. It also gives a superior

finish and appearance to many products where low selling price forbids employment of hand labor. Ball burnishing cuts the cost of handling and is a finishing process that, according to size of article, allows operation upon hundreds of separate pieces at the same time.

Burnishing produces a bright, fairly smooth surface by the action of steel shot rubbing against the parts. It is accomplished by tumbling the work together with steel shot in a wood-lined barrel. Soap and water are added for a lubricant. The size of shot to be used will depend upon several factors. Small balls are more effective but more easily lost. Heavy shot has a tendency to damage small articles, so the size and shape of the pieces affect the choice. For general work $\frac{5}{32}$-inch steel balls are quite satisfactory, although numerous other shapes such as cones, pins, slugs, "pebs," and discs may be used for special purposes. The balls used for burnishing need not be perfectly round; even a flat spot is not objectionable. To burnish well, the balls must be hard and as smooth as it is possible to make them. The ratio of shot to parts should be about two to one by volume.

Work which has been previously cleaned by washing or dipping is placed in the barrel in the above proportion of shot. The barrel is filled about two-thirds full of cold water, and for a barrel approximately 8 inches wide by 30 inches in diameter, about 4 ounces of soap flakes or burnishing soap are added. The barrel is rotated at about 25 r.p.m. to 35 r.p.m. for approximately one-half hour, then opened, the dirty water removed, and the barrel rinsed. Fresh water and soap are then added in the same proportions as for the first operation.

The time of the second rotation will depend on the size of the part, the finish desired, whether or not dipping was used before burnishing, and whether or not a full load is to be burnished.

The following factors must be considered in setting up a standard time for burnishing:

1. Small size screw-machine parts are usually made from small bars. The surface of a small bar is generally better than that of a large one. Consequently, less time is required to get a good finish on small parts than on large ones.

2. With a small charge, the pieces will be in contact primarily with the shot, and more efficient burnishing will be obtained. Pieces which have sharp corners or threads will have a tendency to burr in burnishing, so the burnishing must be restricted in amount to prevent a heavy burr, rounded corners or damage to the threads.

3. Parts which have been dipped will take somewhat longer to obtain a bright surface than parts which have a machined surface. This results from the roughening of the surface by the dip and the fact that the machined surface itself is somewhat bright.

4. The longer the burnishing time, the brighter will be the resulting finish. Consequently, for parts where a very fine finish is desired, burnishing time two or three times longer than normal will be required.

5. As a general rule, the total time of burnishing should average about one and one-half hours; that is, one-half hour in the first tumbling and approximately one hour after rinsing and cleaning the barrel.

No lead should be allowed in the barrel as it tends to coat the shot and is transferred to the pieces, giving a dull, leaden appearance to the work. The barrels should be made of hard wood, since pine or similar soft woods are not suitable for use. Steel shot may become coated with aluminum dust, thus reducing its burnishing efficiency. A change of water is made during the burnishing operation to minimize this difficulty. However, if the shot becomes coated with aluminum, washing it in a caustic solution will remove the coating without affecting the steel.

After burnishing, parts without recesses or threads may be dried and further brightened by tumbling in hard wood sawdust for approximately 15 minutes to 20 minutes. It is necessary to use hard wood, as the pitch in soft wood may affect the surface finish of the parts. Threaded parts or similar pieces should be dipped in benzine and washed in hot water. The excess water is then blown off, and the parts placed on a steam table to dry.

★ ★ ★ FINISHES

CHEMICAL FINISHES

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ANOTHER TYPE of finish used for aluminum involves the use of various chemical treatments. These produce low-cost, protective and decorative finishes resistant to corrosion, but not particularly resistant to abrasion. Such finishing methods include the frosted finish, reflector finish, chemical etching and Alrok* finishes.

FROSTED FINISH

The frosted finish for aluminum has an attractive silvery appearance like that of finely etched glass. It is useful for finishing small or intricately shaped articles not adapted to machine methods. Since it is not permanent, however, and fingerprints easily, it usually needs a further protection such as an Alumilite* finish. The frosted finish is used together with the Alumilite finish on refrigerator trays, and is likewise applicable to many other products.

The first step in the frosting of aluminum is to etch in a hot caustic soda solution. This operation may be carried out in a wide range of conditions depending on the gauge of the metal and the finish required. Immersion for 1 minute in a 15 per cent sodium hydroxide solution at 160° F. to 180° F. is frequently employed, although the concentration may vary from 2 per cent to 25 per cent, and the bath may be heated to boiling. The etching process is greatly accelerated at the boiling temperature, but the caustic may dry in streaks causing stains. To overcome this difficulty in special applications, some manufacturers use a 5 per cent caustic soda solution, followed immediately by immersion in a 2 per cent solution. The second solution is too weak to attack the surface of the aluminum in a short time, and there-

*Patented process.

fore eliminates to some degree the problem of staining. Both the alkali concentration and the bath temperature must be kept reasonably uniform.

After the etching, the metal is rinsed in clear, cold water. If the time between these two steps is kept at a minimum, the caustic dries more uniformly and the danger of staining is minimized. Cold water is preferable to hot water because it, too, lessens discoloration.

The third step is to immerse in strong nitric acid to neutralize any sodium hydroxide left on the surface. A satisfactory solution is made by mixing 2 parts of concentrated nitric acid with 1 part of water. However, concentrations as low as 10 per cent are sometimes used. This part of the process removes the colored film left on the surface by the caustic solution and leaves the metal with a clean, frosted finish.

Again the article is rinsed in clear, cold water and lastly dried on a steam table. Extreme care should be used to prevent watermarks. In some cases air is used in drying.

When aluminum alloys which contain substantial amounts of silicon are to be frosted, it is necessary to add hydrofluoric acid to the nitric acid. One part of concentrated hydrofluoric acid to 8 parts of concentrated nitric acid is a good proportion to use. For alloys 51S and 53S 1 part hydrofluoric and 4 parts nitric acid are added to 56 parts of water. The article to be finished is held in the caustic solution from 2 minutes to 3 minutes, washed in water, then dipped in nitric acid for 15 seconds to 30 seconds, and again washed in water and dried. The hydrofluoric-nitric acid mixture must be used cold. If it becomes too warm during use, it produces a yellow coating which is difficult to remove.

In the case of alloy sheet, particularly that which has been heat treated, the caustic solution does not remove the stains incident to manufacture. The stains can be removed, however, by immersion for 1 minute in a cold solution containing 1 part each of nitric and hydrofluoric acids in 98 parts of water. This is followed by a rinse in cold water and a dip in cold, strong nitric acid. See table on page 32.

DIFFUSE REFLECTOR FINISH

An etched surface having high reflectivity and good diffusing quality for light can be produced chemically. For lighting fixtures used indoors, plain etched reflectors are used with good results. However, when exposed outdoors, the accumulation of dirt on the roughened surface, together with any superficial atmospheric attack may cause substantial loss in reflection efficiency.

Two different procedures are available for etching. In one a solution containing 5 per cent sodium hydroxide and 4 per cent sodium fluoride at a temperature of about 180° F. is used for the first step. After rinsing, the article is immersed in a cold nitric acid solution made up of equal parts of nitric acid and water. The other procedure, less widely used, consists of first etching the aluminum surface with a dilute solution of hydrofluoric acid and then treating with a cold, strong nitric acid solution.

ETCHING

Designs may be readily etched in an aluminum surface. Extensive use of this process is being made in the manufacture of aluminum signs, name plates for motors, vacuum cleaners, etc., and dials for speedometers, vacuum gauges and the like.

In this type of engraving, the areas which are not to be etched are protected by means of a "resist," which will withstand the action of the solution. To form this "resist" the desired design is printed on the aluminum surface with etching ink, the moist surface dusted with 200 mesh asphaltum powder, the surplus shaken off, and the remaining powder removed from the uninked areas with talcum powder. The asphaltum powder is then fused by heating to a temperature of 360° F. to 420° F.

The surface of the article with the protected design is then activated in a 10 per cent solution of hydrofluoric acid, and rinsed. After that it is subjected to the action of a solution which etches the metal in the unprotected parts and engraves the design on the surface. Various etching solutions may be used, but the one which has found greatest favor for action on

PRACTICES FOR APPLYING CAUSTIC ETCHED FINISHES

Step	ARTICLE TREATED					
	Cooking Utensils	Refrigerator Trays with Alumilite Finish	High Silicon Alloys	Screw-Machine Products 2S, 3S, 11S and 17S	Screw-Machine Products 51S and 53S	Alloy Sheet (Heat-treated)
1.	15% NaOH 160° F.—180° F.	5% NaOH 160° F.	15% NaOH 160° F.—180° F.	2%—3% NaOH 180° F.—195° F. Two short dips	2%—3% NaOH 180° F.—195° F. Two short dips	15% NaOH 160° F.—180° F.
2.	Rinse	2% NaOH 160° F.	Rinse	Rinse	Rinse	Rinse
3.	Conc. Nitric Acid Hot	Rinse	8 parts Conc. HNO_3, 1 part HF—Cold	Conc. Nitric Acid Cold	1 part 48% HF 4 parts Conc. HNO_3 56 parts water 2 to 3 min.—Cold	1 part HNO_3 1 part HF 98 parts water
4.	Rinse	Alumilite Finish	Rinse	Rinse	Rinse	Rinse
5.	Dry on Steam Table		Dry on Steam Table	(For 17S repeat series of steps 1 to 4 inc.)	Conc. HNO_3 15—30 sec.	Conc. HNO_3 Cold
6.				Blow with Compressed Air	Rinse	Rinse
7.				Dry on Steam Table or Burnish	Blow with Air and Dry on Steam Table or Burnish	Dry

★ ★ ★ FINISHES

aluminum contains iron chloride and hydrochloric acid. Hydrochloric acid alone may be used effectively in certain cases. However, if the aluminum is not uniformly clean, the attack of this acid may result in a streaked appearance. It is desirable, therefore, to clean the surface with nitric-hydrofluoric acid. If the hydrochloric acid is saturated with sodium chloride, a smoother etch is obtained. The action may be accelerated by adding small amounts of cobalt or nickel chloride to the acid solution. Sometimes the work is dipped in stannous chloride solution (3 per cent to 10 per cent) at about 86° F. for a minute or so. This deposits tin on the aluminum surface. The article is then rinsed and etched as has been described. By these procedures, fine lines can be etched to a substantial depth without loss of definition.

After the work has been etched to a suitable depth, it is removed and rinsed. The background may then be colored with black nickel, enamel, colored Alumilite finishes, or left plain. The "resist" is then removed by suitable organic solvents.

For etching, it is desirable to employ special "etching" sheet.

ALROK* FINISHES

A series of finishes, identified by the trade-mark "Alrok," can be obtained on aluminum and its alloys by chemical processes. These finishes are less resistant to abrasion and corrosion than the electrochemical finishes, but the procedures are less costly and require a minimum of equipment. The coatings may be used as such for their protective value or they may be used as a surface preparation for paint finishes.

The Alrok finishes are either colorless, or a bluish- or greenish-gray. The color may not be entirely uniform because of variations in the metal structure. The protective value of these finishes is enhanced by special inhibitor treatments. They may be dyed, but the colors are not so brilliant as those obtained with the electrochemical finishes.

While Alrok finishes are still in their infancy, they should find numerous applications in industry.

*Produced by a patented process.

★ ★ ★ FINISHES

ELECTROLYTIC OXIDE FINISHES

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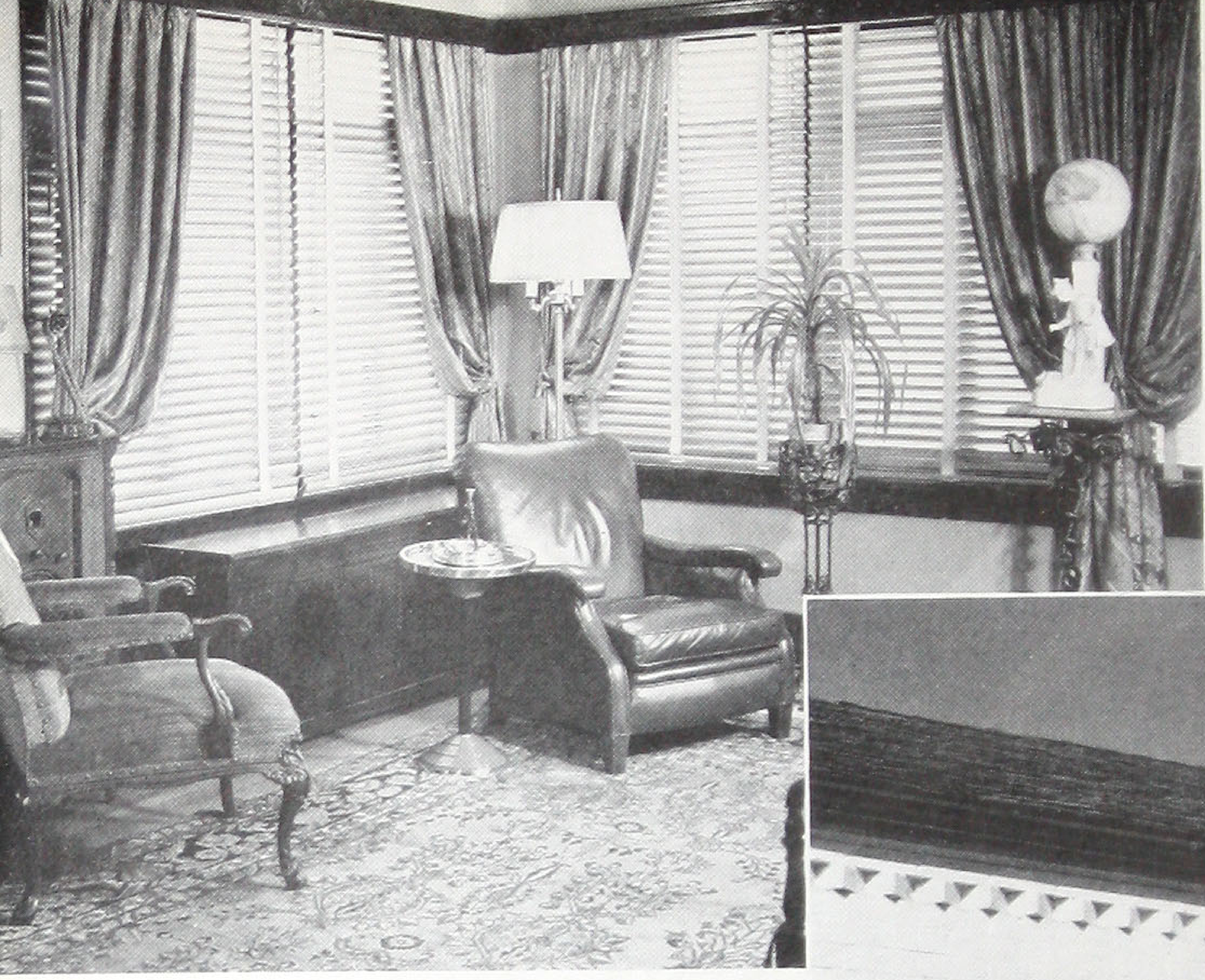
THE OXIDE FINISHES formed on aluminum by anodic treatment in various electrolytes comprise one of the most important classes of finishes for aluminum. The hard corundum-like anodic coatings, which can be formed only on aluminum, are among the most durable of known finishes and give protection and permanence to the surface. They are attractive in appearance, have high resistance to corrosion, high dielectric strength, high reflectivity and good adsorption for dyes and mineral pigments. The properties of the coatings vary, depending on the composition of the alloy, the composition of the electrolyte and the temperature and voltage of operation, as well as the time of treatment.

ALUMILITE FINISH

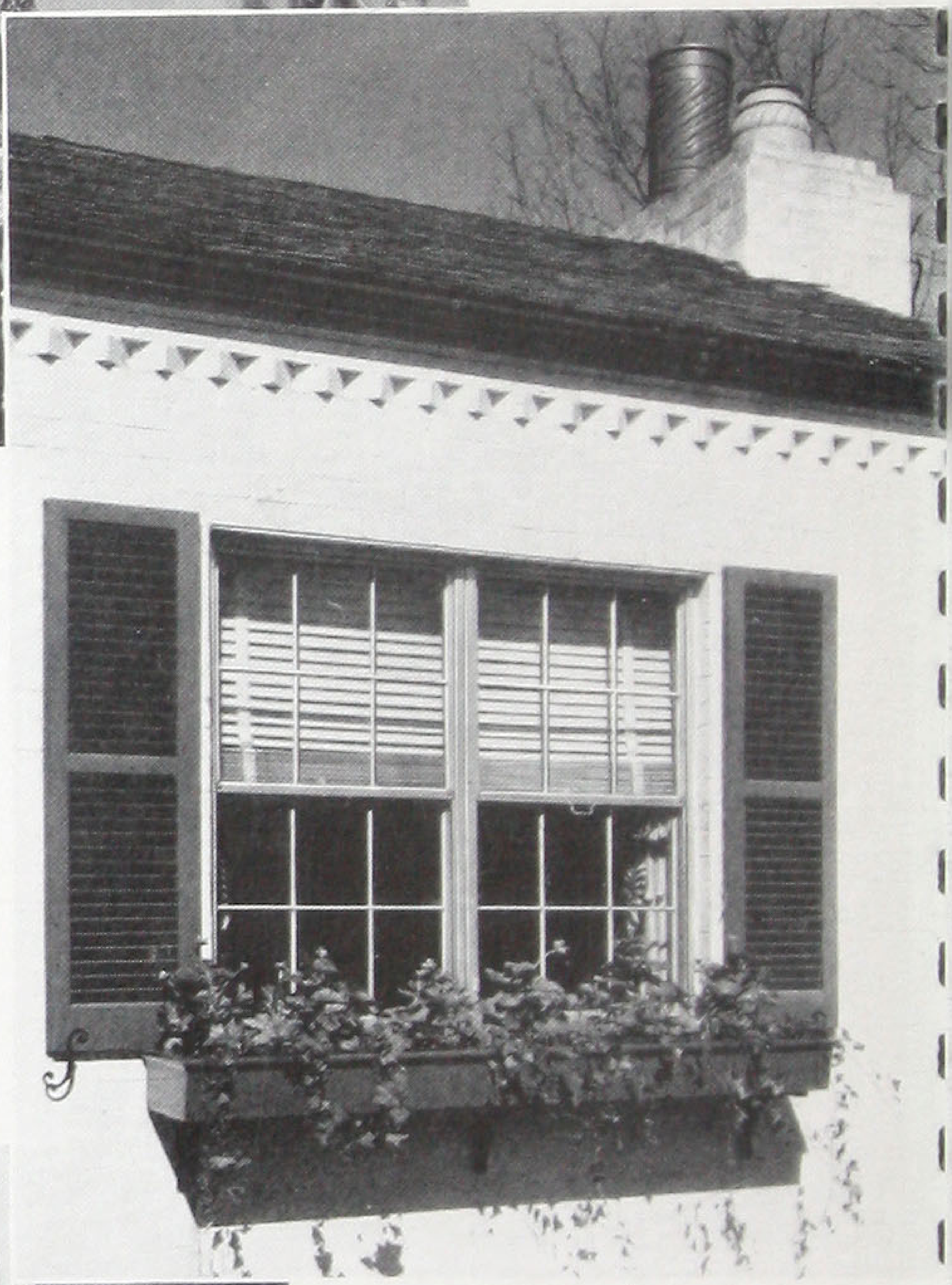
The Alumilite* process is the most practical of the anodic treatments. It is used to produce plain, dyed or mineral-pigment-colored surfaces. It comprises anodic treatment of aluminum in a suitable electrolyte so as to secure a dense, adherent coating of aluminum oxide. The process differs from electroplating in that the articles to be treated are attached electrically as anode rather than cathode in the electrolyte. In electroplating, a metal is deposited on the article being coated, while in anodic treatment, in effect, oxygen is deposited instead of metal and combines with the aluminum to form aluminum oxide, integral with the surface of the metal.

Characteristics of the Finish: One of the outstanding characteristics of Alumilite finishes is high resistance to abrasion. The hardness of the corundum-like finish, applied under suitable conditions, may readily be observed by rubbing with steel wool or

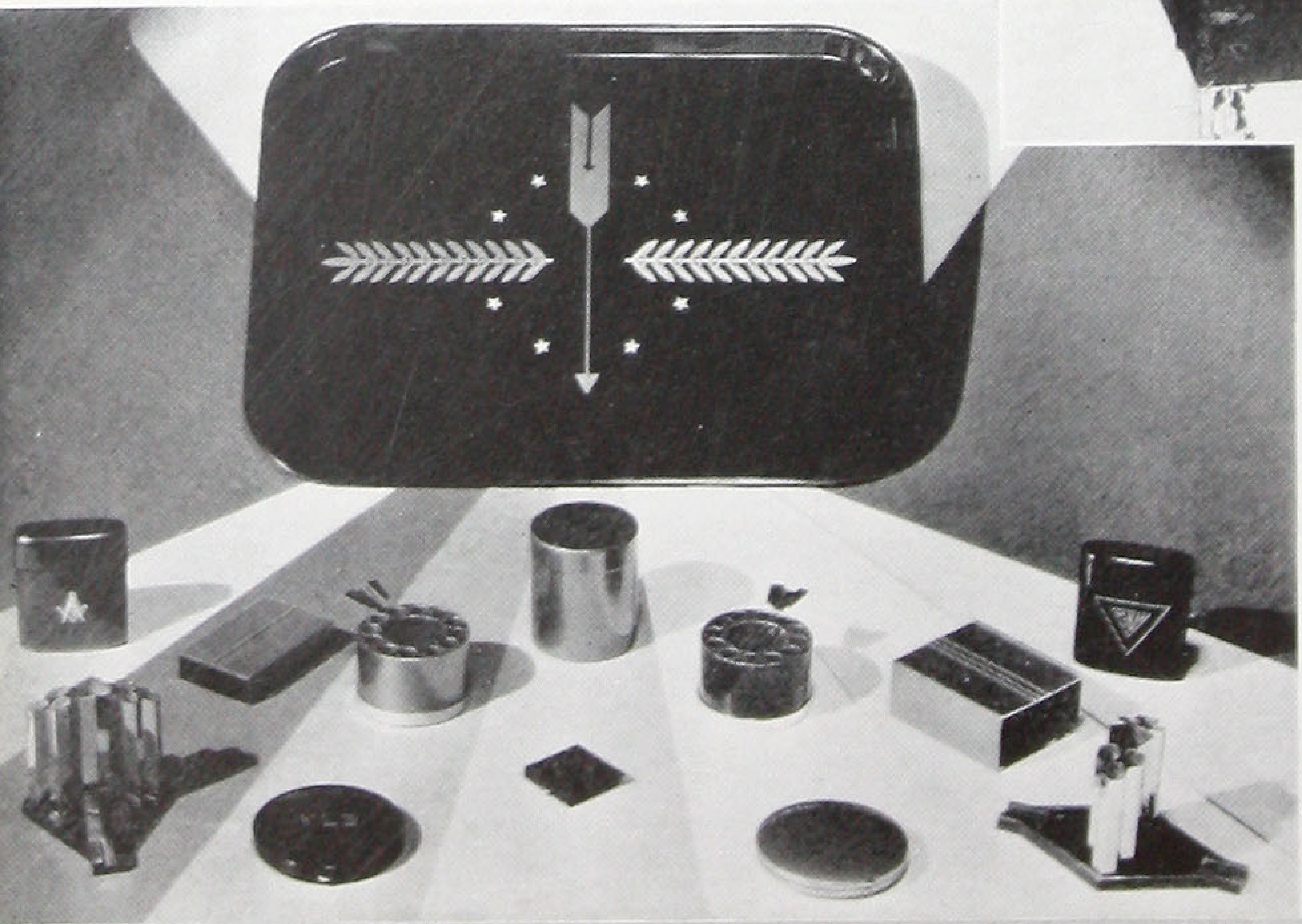
*Patented process for producing oxide finishes.



Venetian blinds made of aluminum add to the decorative beauty of this interior. The smooth, hard surface, resistant to corrosion and easily cleaned. is obtained by the Alumilite process.



Aluminum windows with a plain Alumilite finish are attractive, easily cleaned, resistant to corrosion and do not stain adjoining surfaces.



Household articles are made attractive by both dyed and plain Alumilite finishes.

★ ★ ★ FINISHES

other abrasive material. This hardness is one of the properties that has made the finishes so valuable for cafeteria trays, streetcar handrails, automobile pistons and for numerous other applications where hard surfaces are essential. Quantitative tests on Alumilite finishes with an abrasive wheel have shown them to be among the hardest of finishes.

The value of these finishes is not confined to high resistance to abrasion; they can also be made highly resistant to corrosion. Plain aluminum, when allowed to stand in contact with water for prolonged periods, frequently suffers a superficial attack, and the surface of the metal may take on a dark and stained appearance. On aluminum refrigerator trays, to name only one example, this discoloration is objectionable; an application of an Alumilite finish to the trays, however, provides the desired protection. Alumilite-finished surfaces of certain types are resistant to the corrosive action of moisture and salt water.

For maximum resistance to corrosion under these conditions, coatings should be sealed, preferably in a chromate solution. The chromate sealers* give the coating a yellow color, so can be used only when this color is not objectionable, as for example, where the coating is to be painted. For many purposes, less severe in their requirements, other sealing processes* are available. They are proving useful for architectural parts such as store fronts which must resist atmospheric attack for prolonged periods, and still present a pleasing white appearance.

Some Alumilite coatings are very adsorptive. By immersing an Alumilite-finished article in a suitable dye bath,* it readily adsorbs the color. The dye penetrates the coating, giving deep colors which have an attractive underlying metallic sheen. It is, of course, recognized that these dyed coatings, similar in this respect to dye in fabrics, will eventually fade on continued exposure to the weather. These colored finishes are best used for interior service. Cocktail shakers, inlay material for plastics, automatic pencils, fountain pen parts, ash trays, cigaret cases and compacts are some examples of their use. Two-colored fin-

*Patented processes.

Alumilite-finished store fronts and entrances are economical to maintain, do not stain adjoining surfaces and harmonize with modern architectural design. Many standard moldings are available.

Polished and Alumilite-finished escalator housings in Marshall Field and Co., Chicago.

★ ★ ★ FINISHES

ishes, or contrasting colored and uncolored sections, make pleasing effects for decorative work. Portions of the design are stopped off while the other part is being finished, as is done in the etching process described in the preceding chapter.

For more severe service, mineral pigment may be adsorbed in the coating.* These colors are not usually as brilliant, nor do they produce the translucent effect of the dye colors, but they possess a greater light fastness. Such coatings are now in outdoor service for lamps on bridges, for statues and for other architectural applications. They retain their color satisfactorily for at least several years, although their ultimate life is not yet determined.

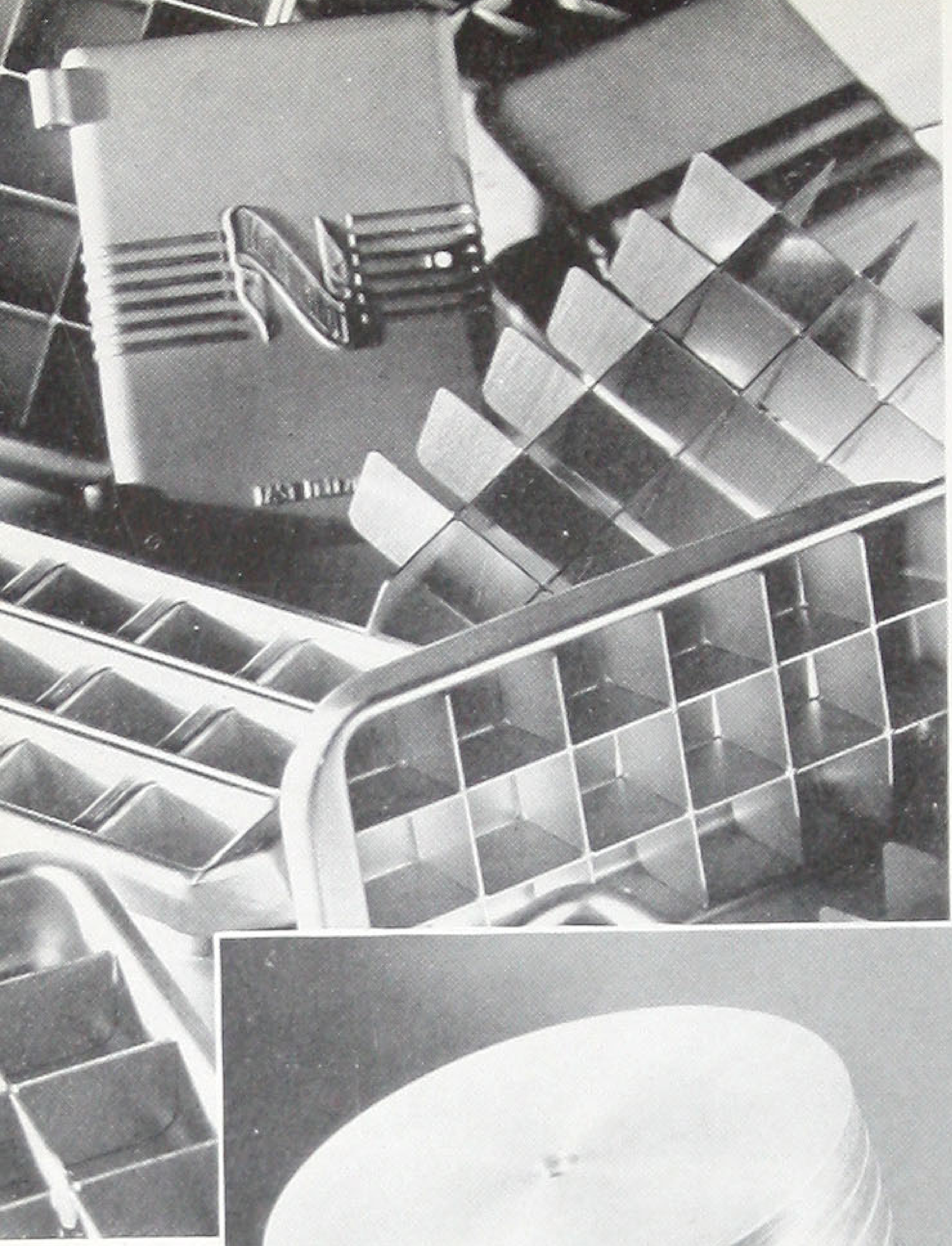
A sealing treatment may be used on Alumilite finishes which has a considerable advantage for certain types of products. For example, the adsorptive characteristic of Alumilite finishes would be undesirable on refrigerator or cafeteria trays, because grease and food coming in contact with them would stain the finish. The sealing treatment, however, makes it non-adsorptive and stainproof. This treatment effects a change in the structure of the coating, which gives a marked increase in its resistance to corrosion.

Hard Alumilite finishes are not adaptable for certain forming operations, because of cracks which occur at relatively sharp bends. By the proper selection of the electrolyte and the coating conditions, however, it is possible to produce a finish that may be fabricated without visible cracks, but resistance to corrosion is sacrificed by this procedure.

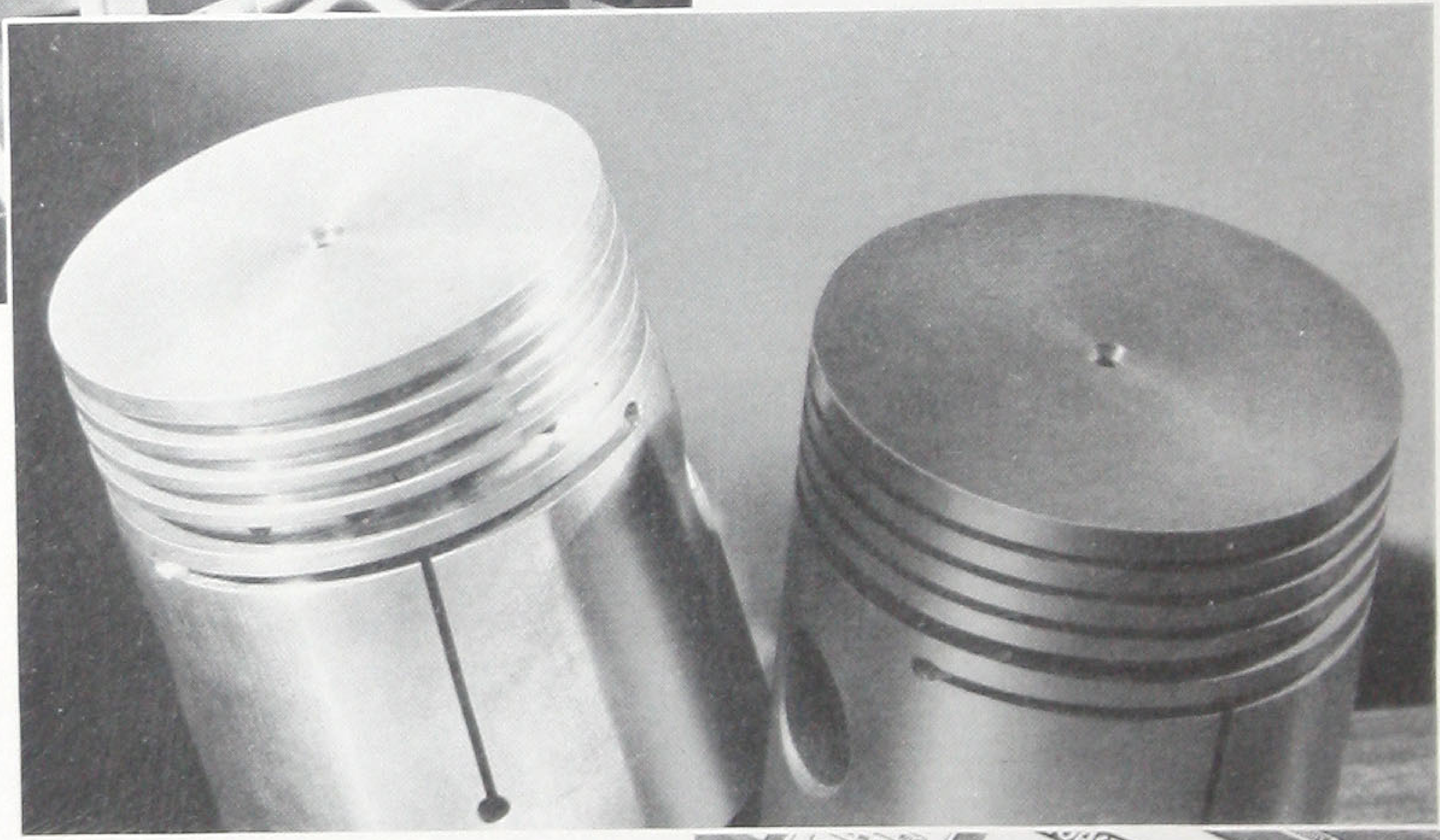
The coating of large, flat sheet surfaces presents special problems. During anodic treatment, structural markings, traceable to the grain of the metal, may become prominent. This effect will usually be concealed by making uniform markings on the surface. Fluted sheet, for example, does not show these structural markings. Finishing with coarse steel wool, prior to anodic treatment, also reduces the streaks on certain types of sheet.

When dirty, the surfaces of Alumilite-finished articles usually

*Patented processes.



Aluminum refrigerator trays and evaporator doors are finished by the Alumilite process. With this finish, the trays are resistant to the corrosive action of tap water and the evaporator doors are made permanently attractive.



Aluminum automobile pistons before and after the Alumilite finish is applied. The Alumilite process gives the pistons a hard but velvet-like surface highly resistant to abrasion.

A practical use of the Alumilite process is shown by these colored aluminum name plates.

can be restored to their original appearance merely by wiping or rubbing with a cloth. However, when grease and food stains are present, as on cafeteria trays, a more thorough cleaning is necessary. The cleaner should be selected with care, for many alkaline cleaners dissolve the coating. The fact that these cleaners may contain inhibitors which prevent attack on metallic aluminum does not insure their safe use on Alumilite finishes.

In reviewing this discussion of properties of Alumilite finishes, the outstanding feature is the versatility of the finish. Both adsorptive and non-adsorptive finishes may be formed at will. A wide variation in degree of thickness is available. All this means that plain or colored coatings suitable for a wide variety of uses can be obtained with the Alumilite process.

Color Matching of Alumilite Finish: Where a structure is composed of several parts, fabricated in different ways, the selection and finishing of these various parts present a definite problem where accurate color matching is required.

The appearance of an Alumilite finish is affected to a large extent by the original surface of the metal. Different effects are obtained on buffed, frosted, satin-finished, and sandblasted aluminum. As a general rule, the rougher surfaces appear darker after being given an Alumilite finish. Very often these surface differences may serve to secure attractive contrasts, but, where an acceptable match is required, great care must be used to see that the proper surface preparation is employed before applying the Alumilite finish.

Generally, plain Alumilite finishes have an attractive silvery-white appearance. There is, however, some variation in the color when different alloys and tempers are treated, since the alloying constituents affect the color of the finish. The presence of a considerable content of silicon in the metal may result in a gray or almost black tone; chromium gives a yellowish cast. The amount of the alloying constituent alone, however, is not the only factor that affects the color; the condition of the alloying constituent in the metal is equally important. Among the heat-

Many pieces of aluminum hospital equipment, such as trays, pans, and basins are finished by the Alumilite process. This finish provides a smooth, hard surface that will not chip and which is easily kept clean and sanitary.

treatable alloys, it is found that in the heat-treated tempers the color of the Alumilite finish is lighter, as a rule, than when the metal is not heat treated. As a result of these conditions, care must be exercised in making up assemblies of different alloys to be certain that the shades of color will match or harmonize. In some instances, this coloring effect may be turned to advantage, and in the case of certain silicon alloys attractive dark colors may be obtained in the finishes.

In architectural applications it is generally necessary to employ, in close proximity, parts fabricated in various ways, and still maintain a uniform appearance in the structure. For extruded parts, 53S alloy is most commonly used, and generally in the "as-extruded" form. Castings of B214 alloy with an Alumilite finish match the coated 53S reasonably well. The sheet to be used in assemblies may be either 2S or 3S, but preferably the former. As has been discussed earlier, special preliminary finish-

ing operations are often employed to make the structural markings of the sheet less noticeable.

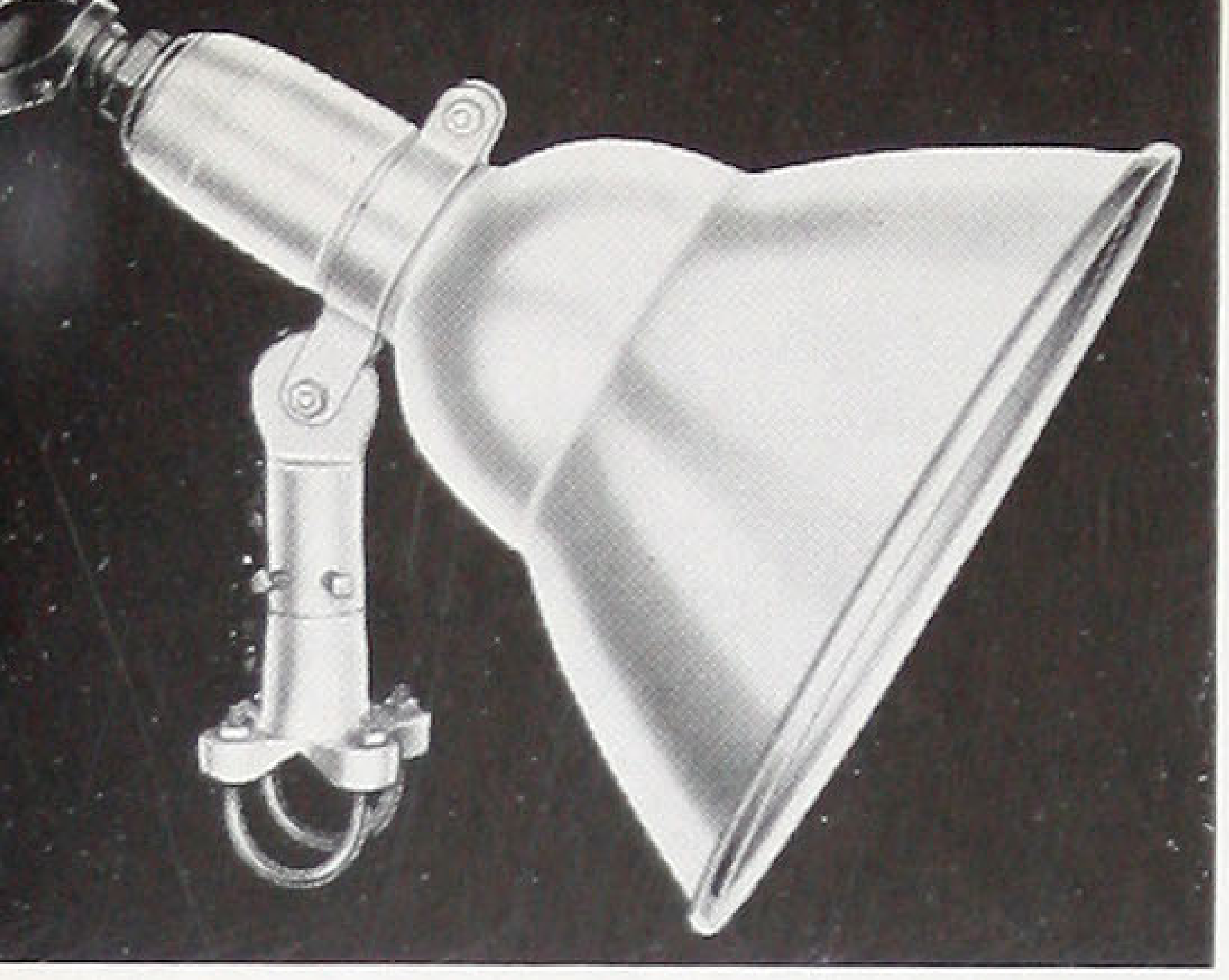
With special reference to castings, it is obvious that to obtain a satisfactory appearance the castings should be as dense and fine grained as possible; any porosity or lack of uniformity will be particularly pronounced in the Alumilite finish.

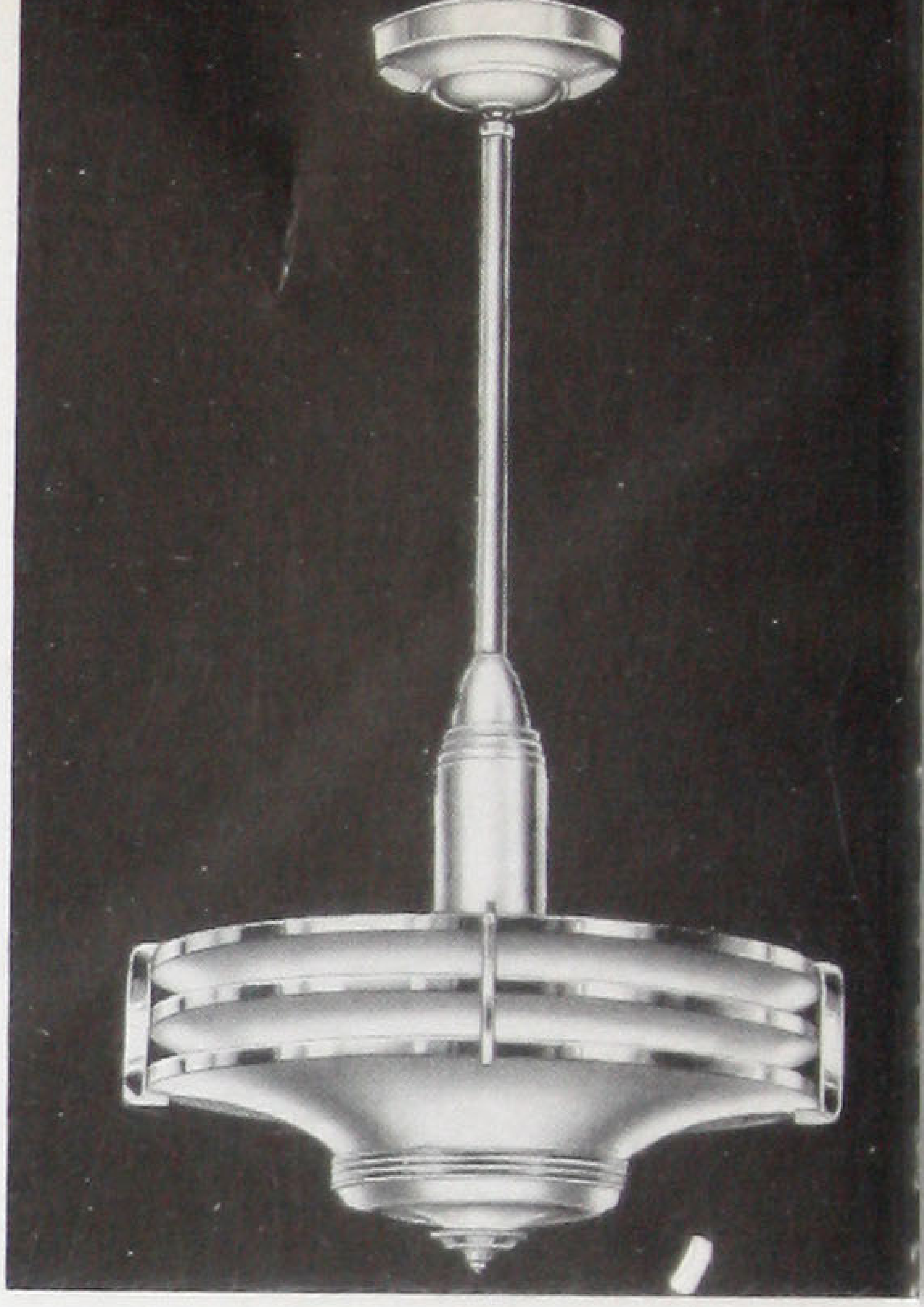
Frequently it is necessary to weld parts that are to be finished by the Alumilite process. To secure welds of satisfactory appearance, special precautions are necessary. Where 53S is welded, 2S wire must be employed in place of the silicon alloy wire which might ordinarily be used. Even with this wire, the weld may be noticeable. It is therefore beneficial to apply a coarse-ground finish to the part to make the weld less apparent. For example, the weld is far less noticeable on a surface ground with No. 120 emery than where the surface is buffed.

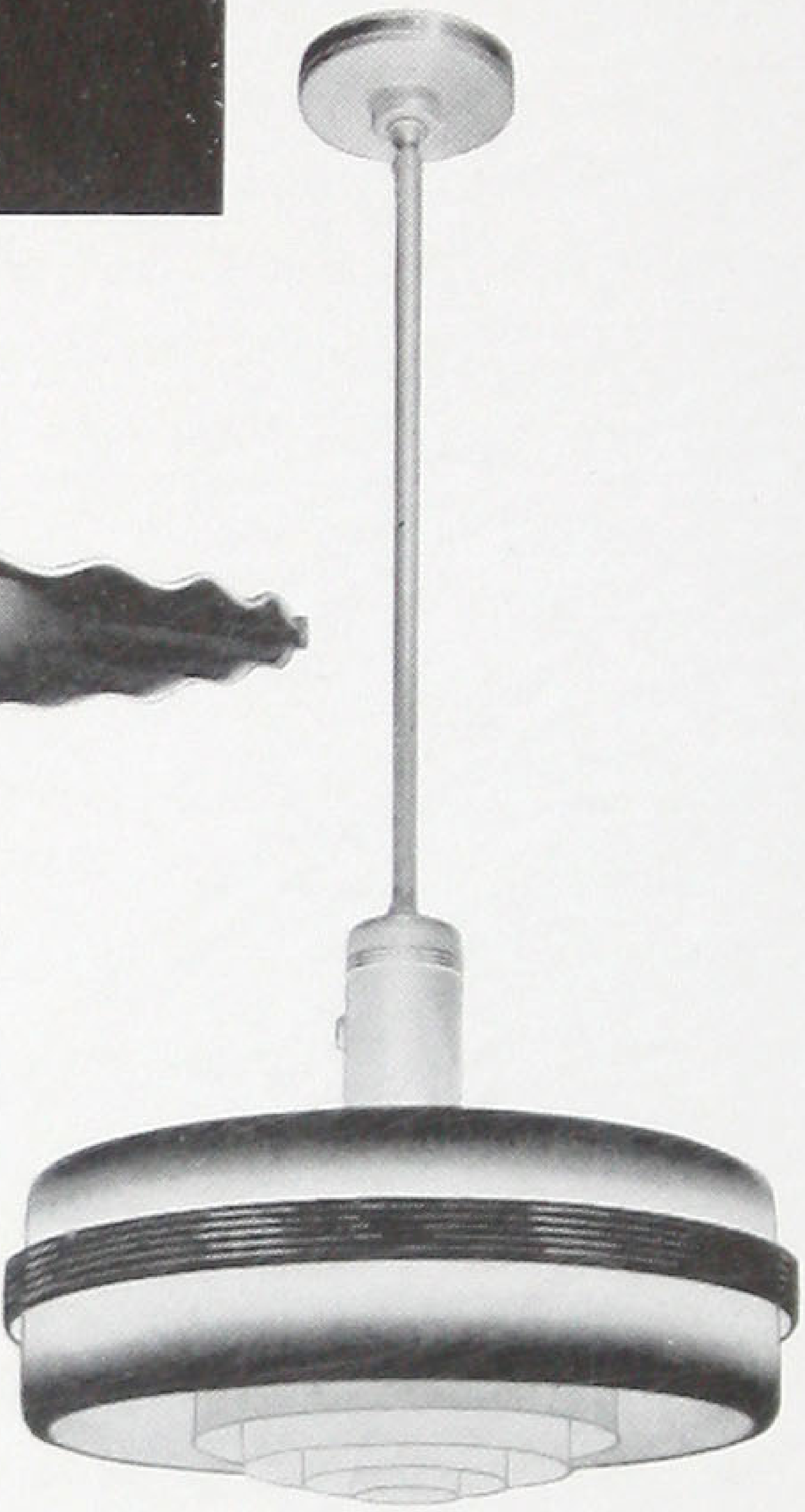
The Coating Process: The material to be coated comes to the Alumilite-finishing room with some suitable mechanical finish, which is designed to give the desired appearance in the completed article. It must first be cleaned. Organic solvents, solutions of mild alkalis or caustic soda may be used for this purpose. If a buffed surface is being cleaned, however, it is necessary to select the cleaning conditions that will minimize any attack of the aluminum.

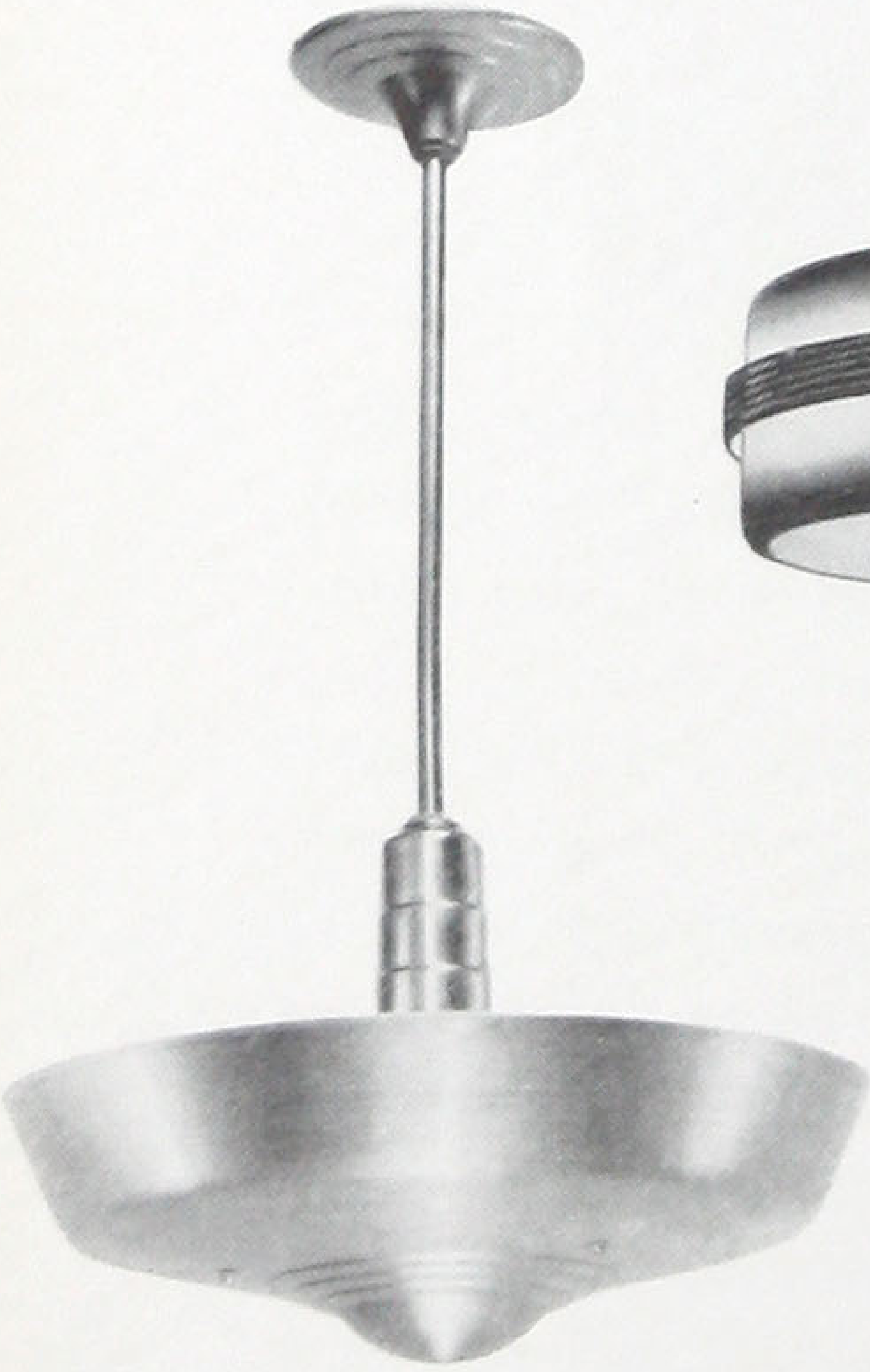
The work, after coming from the cleaning bath, is rinsed in water and treated as anode in a certain acid electrolyte. The time of treatment in this solution usually varies from 10 minutes to 50 minutes.

After the anodic treatment has been completed, the finish may be left as it is if staining will not be objectionable, or it may be sealed or colored. The sealing and coloring operations are simple treatments in certain chemical solutions. The coloring may be performed in one of two ways. Dyes may be applied by immersing the anodic-treated articles in the dye bath for a few minutes. Usually dyed finishes are sealed to prevent subsequent staining. To apply mineral pigments two or more dips are re-

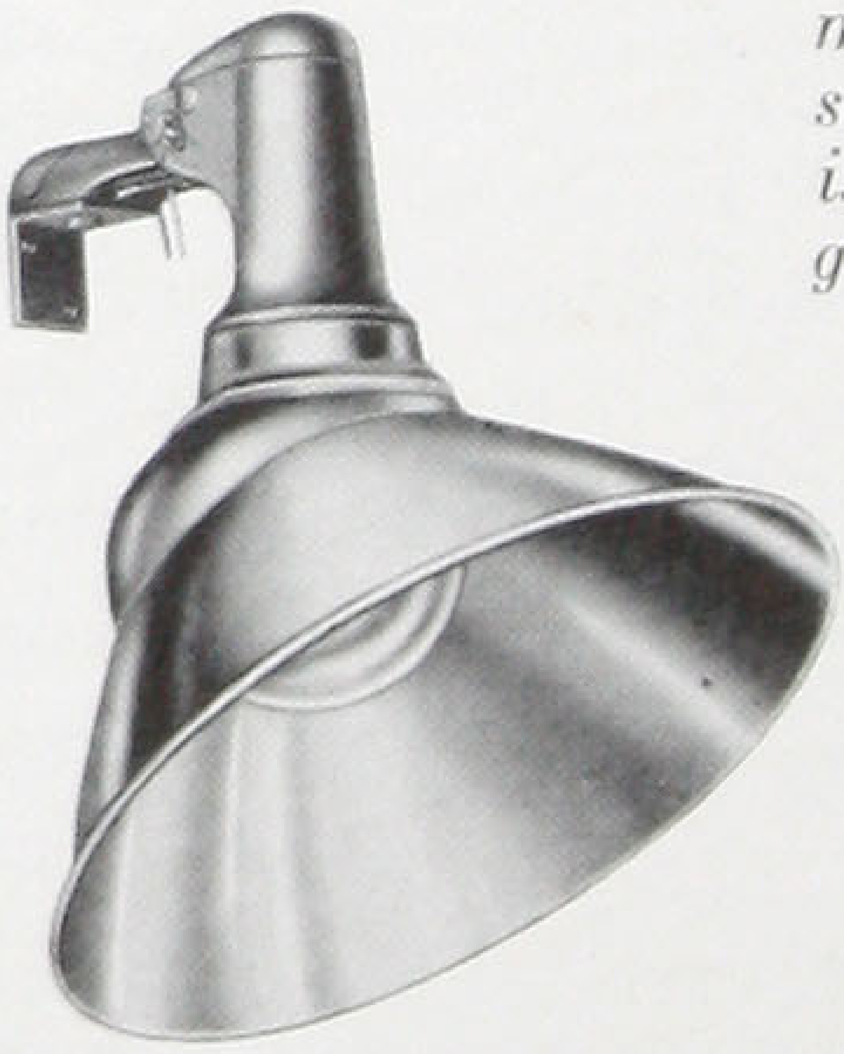


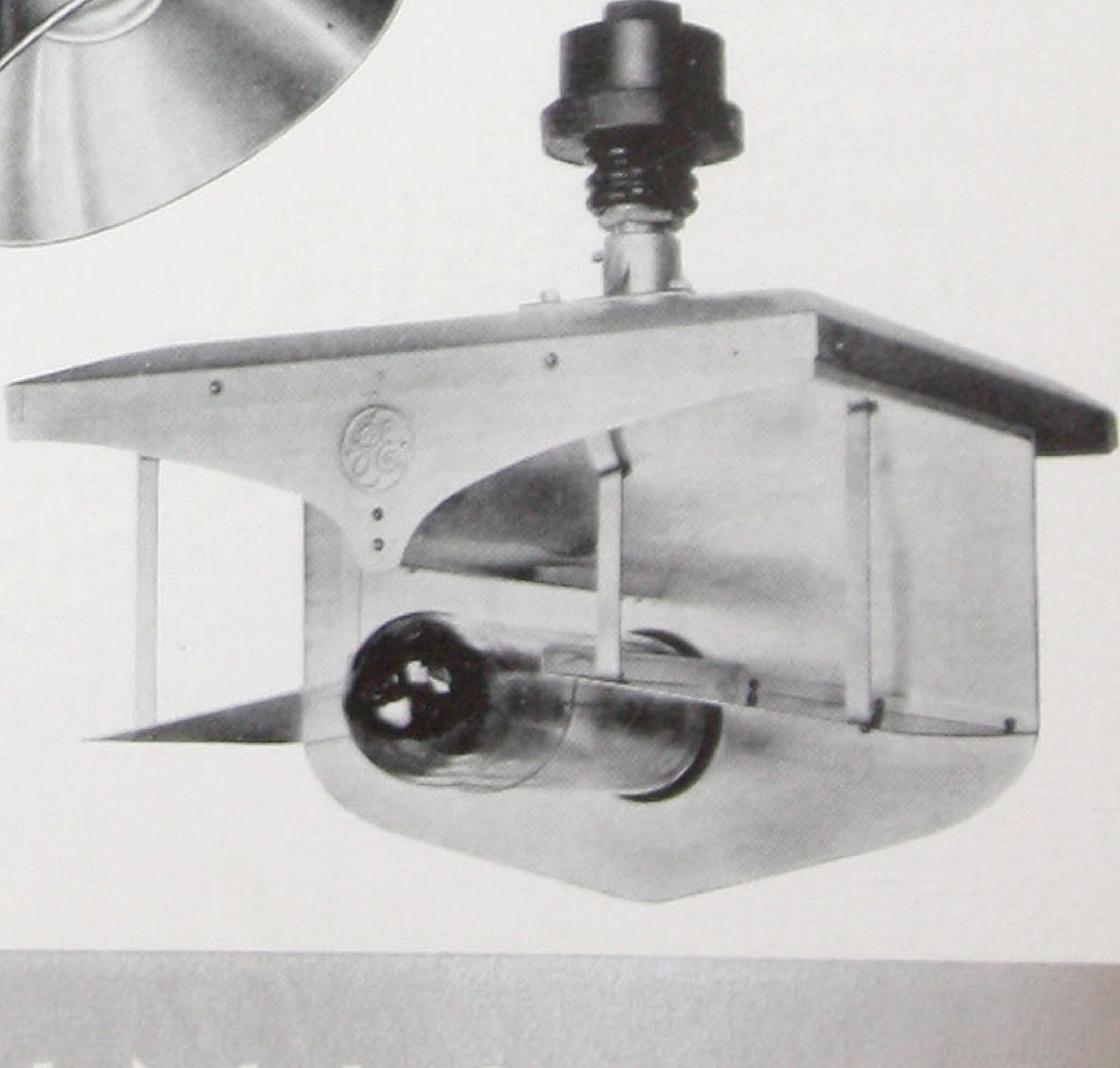






Aluminum is used extensively in many types of lighting equipment. When finished by the Alzak process (patented), light-reflection efficiencies of as high as 85 per cent are obtained. Illustrated are a few of the types of Alzak reflectors. Their original high efficiency may be maintained even under severe exposure conditions. Dirt is easily washed from their glasslike surface with little or no loss in reflectivity.





★ ★ ★ FINISHES

quired. The mineral-pigmented finishes may or may not be sealed. Generally, the work should be wiped or buffed at the end of the coating procedure.

The Alumilite process is easy to use and any plater can learn to handle it after proper instruction. As a result, it has become an outstanding method for finishing aluminum. The various steps in the process are covered by patents, and information as to their use may be obtained from Aluminum Company of America.

ALZAK* REFLECTORS

Alzak aluminum reflectors are characterized by a combination of permanence and high reflectivity not obtainable by the older finishing methods for aluminum reflectors. An oxide coating provides the surface protection and the high reflection factors are the result of a special electrolytic treatment** of suitable sheet prior to applying the anodic finish.

The reflection efficiencies of Alzak reflectors as now made are about 80 per cent to 85 per cent for the specular finish, and 75 per cent to 80 per cent for the diffuse finish. In addition to highly specular surfaces produced by polishing, and diffuse or matte surfaces produced by etching, it is possible to obtain gradations of surface intermediate between the two extremes.

Alzak reflectors, properly maintained, retain their high efficiency under severe conditions of temperature and exposure, and the hard, glasslike coating permits cleaning methods not suitable for untreated aluminum reflectors. Soap and water will remove normal accumulation of dirt. When necessary, however, a mild abrasive or a wax emulsion can be used to restore the brilliant finish. Where the reflector is exposed to the weather, accumulations of dust and dirt should be removed by cleaning at regular intervals to prevent attack of the coating.

Further information concerning the commercial availability of Alzak reflectors may be obtained from the nearest sales office of Aluminum Company of America.

*Registered trade-mark. **Patented process.

★ ★ ★ FINISHES

ELECTROPLATING ON ALUMINUM

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DECORATIVE electroplates on aluminum, such as bright chromium, nickel and oxidized copper, are used primarily for ornamental purposes. They add nothing to the resistance of aluminum to corrosion; in fact the plated material has lower resistance to corrosion than plain aluminum if there is any lack of continuity in the coating. Such electroplates, while they are perfectly satisfactory where the corrosion conditions are not too severe, may not be satisfactory for continuous outdoor exposure.

Chromium applied directly on aluminum has several desirable characteristics. The coatings are ornamental, have high resistance to abrasion and resist alkaline solutions particularly well. However, they are not very satisfactory against atmospheric corrosion.

Zinc electroplated on aluminum has no adverse effect on the metal's resistance to corrosion, and has been used to improve the electrical contact characteristics of the aluminum surface.

ZINC PLATING

Zinc is plated on aluminum in a thin layer from a special cyanide solution. Plating may then be continued in any plating bath that is suitable for plating on zinc. Where zinc alone is the metal coating, the plating is quite resistant to corrosion, but when other metals such as nickel or copper are applied over the preliminary zinc coating, the product does not resist corrosion well, but is likely to blister or peel on exposure to moisture, because of the difference in electrolytic solution potential between these metals and aluminum.

Heat treatment, so that the coating will alloy itself with aluminum, may be used to make copper, plated over the zinc "flash," more resistant to corrosion, but this procedure has the disadvantage of adding to the cost and in some cases may affect the temper of the alloy.

Plating on aluminum after a cyanide zinc "flash," except for zinc alone, can be recommended only for a limited type of service. Such deposits would be quite satisfactory for indoor use, and can be considered durable where such service conditions are fairly dry.

The zinc alone, on the other hand, has been used to resist certain types of corrosion. Such a deposit has also been employed for radio shield cans to effect a special type of contact between the chassis and the can.

The plating procedure for applying the preliminary zinc layer is as follows:

1. Clean the metal surface by a short immersion in a cleaner containing 1 ounce to 3 ounces per gallon each of sodium carbonate and trisodium phosphate. The cleaner is used at a temperature of 180° F. to 200° F.

2. Rinse in clear, cold water.

3. Treat for 1 minute in 5 per cent hydrofluoric acid at room temperature. The etching effect of this solution appears necessary for good adhesion of the plate.

4. Rinse in clear, cold water.

5. Apply a thin coating by plating from 1 minute to 10 minutes at a current density of 1 ampere to 5 amperes per square foot, in the following bath:

Zinc cyanide ($Zn(CN)_2$)	4 ounces per gallon
Sodium cyanide ($NaCN$)	4 ounces per gallon
Ammonium hydroxide (NH_4OH) (sp. gr. 0.90)	4 ounces per gallon
Peptone	1/8 ounce per gallon

6. The plating may then be continued in solutions suitable for plating on zinc, such as cyanide-copper, nickel or acid-zinc.

If zinc alone is the coating metal, it is usually best to continue the plating in an acid bath because of the greater speed of plating, and because the acid bath does not attack the aluminum through the coating.

CHROMIUM APPLIED DIRECTLY ON ALUMINUM

Thin chromium plates can be readily applied directly to aluminum from an ordinary chromium bath at about twice the usual current density used for plating over nickel. For cleaning, a short treatment in the alkaline cleaner, already mentioned for zinc plating, followed by immersion in hydrofluoric acid, is all that is required. A slight attack of the aluminum appears necessary in securing an adherent deposit. With certain of the casting alloys, an additional treatment in nitric and sulfuric acids, or nitric and hydrofluoric acids, is required to whiten the surface. The chromium invariably comes from the bath with a dull gray color. When plated from a hot solution (118° F.), the chromium is lighter in color than when plated from a cold solution (80° F.), but the deposit from the cold solution is much more readily polished to a high luster. This finish is not quite equal in brightness to chromium over nickel, but has numerous applications. Not all chromium polishing compounds are equally satisfactory for polishing this finish. Tests of the materials of the various manufacturers will indicate the most suitable compound.

NICKEL PLATING

A preliminary nickel plate may be employed as a foundation for any other plate. Chromium applied over buffed nickel is brighter and more attractive than when it is applied directly to the aluminum.

The nickel plate should be applied to a specially roughened aluminum surface. It is not sufficient simply to produce an irregular surface such as might result from sandblasting. It is necessary to produce a roughened surface in which the irregularities and pits are undercut into the aluminum, so that the coating electrodeposited in these undercut openings will be satisfactorily keyed or anchored to the surface. A structure of this character is produced with special etching reagents. The reagent dissolves certain portions of the surface selectively, and the number, character and placing of these openings are greatly af-

Various methods of finishing, including black nickel plating, plain etching and coloring by the Alumilite process, are employed in the manufacture of aluminum name plates.

Chromium applied over nickel-plated aluminum gives a permanent non-tarnishable finish to these utensils.

★ ★ ★ FINISHES

fected by the composition and temper of the metal or alloy which is being etched.

Procedure employed for applying the nickel:

1. Alkaline Cleaning: A very good cleaner has equal amounts of the following constituents:

Sodium carbonate (Na_2CO_3)	1 ounce to 3 ounces per gallon
Trisodium phosphate (Na_3PO_4)	1 ounce to 3 ounces per gallon

This cleaner is used at 180° F. to 200° F. If the concentration of the cleaner is appreciably above the recommended value, subsequent plates may be hard to buff; however, the strength of the cleaner should be as high as possible to insure rapid and complete removal of grease, without affecting the plate.

2. Rinse: After cleaning, the metal is rinsed in clear, cold water.

3. Acid Cleaning: Generally, it is advisable to follow the alkaline cleaning by an acid cleaning. This is most readily accomplished by treating for 10 or 15 seconds, in a 5 per cent hydrofluoric acid solution, made up of 1 part of 50 per cent hydrofluoric acid to 9 parts of water. The proper timing, temperature and strength of acid for this acid cleaning should be established and should be adhered to as changes will affect the later etching of the surface. If the etching solution is, however, the one containing strong nitric and hydrofluoric acids, this hydrofluoric acid cleaning is unnecessary and may be omitted.

4. Rinse: The metal is again rinsed in clear, cold water.

5. Roughening of the Surface: The choice of solution used to roughen the surface before plating depends on the aluminum alloy being plated. Three commercially used etching solutions are:

Nickel Solution—For commercially pure aluminum (2S) sheet

Nickel chloride ($NiCl_2.6H_2O$)	36 ounces
Hydrochloric acid (HCl) (sp. gr. 1.18)	0.2 gallon
Water	1.0 gallon
Temperature	90° F.
Time of treatment (approximate)	15 seconds

Manganese Solution—For aluminum alloy sheet and other wrought materials

Hydrochloric acid (HCl) (sp. gr. 1.18)	1/3 gallon
Water	2/3 gallon
Manganese sulfate ($MnSO_4.2H_2O$)	1/2 ounce
Temperature	90° F.
Time of treatment (approximate)	15 seconds to 30 seconds

Acid Solution—For castings

Nitric acid (HNO_3) (sp. gr. 1.43)	3 parts
Hydrofluoric acid (HF) (48%–52%)	1 part
Temperature	75° F. to 80° F.
Time of treatment:	
Die Castings	15 seconds to 30 seconds
Permanent-Mold Castings	30 seconds to 90 seconds
Sand Castings	60 seconds to 120 seconds

The time of treatment in each of these solutions must be carefully determined by experiment, as this is the most important step in the plating procedure. This is accomplished by plating a series of specimens etched for different lengths of time and then bending or breaking them. A good deposit does not flake off under this treatment. If the time of etching is too short, the deposit does not adhere, while if it is too long, the deposit is rough and cannot be readily buffed.

In the etching treatment the two most important factors to control are the temperature and the acidity. Since even slight changes in the temperature cause a considerable change in the time which is required for best results, temperature should be held constant or the time of treatment should be varied to correct for temperature changes. The acidity should be kept as nearly constant as possible. Where a solution is being used continually, more frequent replacements of the acid consumed in etching the aluminum are necessary.

The gauge of metal being treated is also a factor that affects the etching time. Thin sections are acted upon more rapidly than thick ones, probably because they tend to heat more readily, there being a smaller weight of metal to absorb the heat of reaction. Hard-rolled sheet generally requires greater care in etching than soft metal.

Occasionally metal will come from the manganese etch with a dark film on the surface caused by the alloying constituents. This can be brushed off or removed by treating in concentrated nitric acid or a nitric and sulfuric acid mixture.

There are also differences among the alloys; 51S being the most readily plated. 17S-T alloy is readily plated in the form of screw-machine products, but often gives trouble in sheet form because of metal streaks.

The containers for the acid etching reagents should be lead-lined and should also be painted with a mixture of 1 part beeswax to 4 parts paraffin. This is particularly necessary above the solution line, where the attack of the lead takes place.

6. Rinse: The metal is rinsed in clear, cold water. A double rinse is desirable for keeping acid out of the plating bath.

7. Nickel Plating: Various nickel baths may be used for plating aluminum. A bath which has been used considerably in the past is as follows:

Nickel sulfate ($NiSO_4.7H_2O$)	19 ounces per gallon
Magnesium sulfate ($MgSO_4.7H_2O$)	10 ounces per gallon
Ammonium chloride (NH_4Cl)	2 ounces per gallon
Boric acid (H_3BO_3)	2 ounces per gallon
Temperature	90° F. to 95° F.
Current density	15 amperes per square foot
pH (Colorimetric)	5.8–6.0

More recently the following bath has been used with excellent results:

Nickel sulfate ($NiSO_4.7H_2O$)	45 ounces per gallon
Nickel chloride ($NiCl_2.6H_2O$)	2.28 ounces per gallon
Boric acid (H_3BO_3)	4 ounces per gallon
Current density	30 amperes per square foot
pH (Potentiometric)	2.0–2.5
Temperature	140° F. to 150° F.

To overcome a tendency toward pitting, frequent additions of hydrogen peroxide are necessary (0.053 ounce of 30 per cent solution of hydrogen peroxide per gallon of electrolyte; the hydrogen peroxide should be diluted with water before adding to

the bath). An excess should be avoided, for it results in embrittlement of the deposited nickel and reduces throwing power.

The deposited nickel should be smooth and velvety in appearance, and readily buffed to a high luster. The usual lime buffing compositions may be used.

Heat treatment of nickel-plated aluminum parts affords a distinct improvement in adhesion of the nickel deposit. For the common wrought alloys, a heat treatment of 6 hours at 300° F. is suggested.

For a deposit on aluminum that must stand moderate outdoor service, a thickness of at least 0.001 inch is recommended. Generally, the thicker the deposit, the more resistant to corrosion it will be.

Other Metals on Aluminum: As has been mentioned earlier, the nickel deposit may serve as the foundation for a variety of other plates. Certain observations are warranted in connection with the metals most commonly plated.

Chromium may be readily applied over nickel from the ordinary chromium baths now being used commercially. Experience indicates that a deposit of about one and one-half minutes is advisable. Longer plating times may raise a few tiny blisters on a small percentage of the plated articles, particularly if the nickel is thin. Tests have indicated that these articles are satisfactory in resistance to corrosion.

Copper may also be readily applied over the nickel from either a cyanide or an acid bath. Generally, the acid bath is better, for it has less tendency to undermine the plating.

Brass may be applied to the nickel, but because of the tendency for some cyanide baths to undermine the plating, particularly good nickel plating is needed.

Silver, as well as numerous other metals, may be readily applied to the nickel.

Colored or oxidized finishes may be obtained on these deposits by the usual procedures. In a few instances, where the coloring solution is strongly alkaline, it is advisable to reduce the strength of the alkali.

Black Nickel: Black nickel plating may be applied directly to aluminum. Such a finish is commonly used on the etched background of aluminum name plates. The coating is sufficiently durable for interior service, but is not of much value outdoors. A typical black nickel solution which may be employed on aluminum is:

Nickel ammonium sulfate ($NiSO_4.(NH_4)_2SO_4.6H_2O$)	8 ounces per gallon
Zinc sulfate ($ZnSO_4.7H_2O$)	1 ounce per gallon
Sodium sulfocyanate ($NaCNS$)	2 ounces per gallon

Nickel anodes are used in the solution. The voltage is about 1 volt, and the current density 1 ampere to 2 amperes per square foot. The solution is kept nearly neutral by the use of zinc carbonate.

TESTS OF DEPOSITS

It cannot be overemphasized that the successful plating of aluminum can only be accomplished when regular and severe tests of the quality of the plate are made at frequent intervals. This is necessary because it is so easy to obtain deposits on aluminum which have a nice appearance, but, nevertheless, are of little value. Regular checks on the adhesion and resistance to corrosion of the coatings should be made at frequent intervals.

★ ★ ★ FINISHES

ALCLAD PRODUCTS

★

"ALCLAD" is a registered trade-mark used to identify duplex-metal products sold by Aluminum Company of America which are unusually resistant to corrosion.

These products are made by bonding a layer of high-purity metal, or a special aluminum alloy, to the surface of a base of aluminum or aluminum alloy, until it becomes an integral part thereof. The thickness of this surface layer is carefully selected so that the final product will provide satisfactory resistance to corrosion and retain substantially the physical characteristics of the basic metal. While the tensile and yield strengths are somewhat lower in this material, this may be compensated for, if necessary, by using a slightly thicker gauge of sheet.

Alclad products are so durable that they have withstood the corrosive action of 5 years' exposure to salt spray in the laboratory without loss of mechanical properties. The protection given by the coating is also sufficient to prevent, by electrolytic action, corrosion of the base alloy at the sheared edges of the sheet as well as other sections that have become exposed by scratching. There is, however, some solution of the pure aluminum surface layer at these broken or exposed areas. The corrosion spots are only superficial and can be readily removed without destroying the protecting surface.

This product can be in the form of aluminum sheet and plate, and is extensively used for airplane parts. Where the sheet must meet the most severe service requirements, it may be further protected by painting or even by anodic treatment followed by painting.

There are advantages, for some applications, in substituting certain aluminum alloys for the high-purity aluminum in the surface coating. This change is made when increased abrasion resistance is required as well as good resistance to corrosion.


ENCORE
SLICED
BEEF
WAFER
MERCK
MERCK
O.F.C.
KITCHEN BOUQUET
Cream of Kentucky
REG. U.S. PAT. OFF.
TEAR TAB DOWN
to prevent
caking

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PAINT, LACQUER AND ENAMEL FINISHES

★

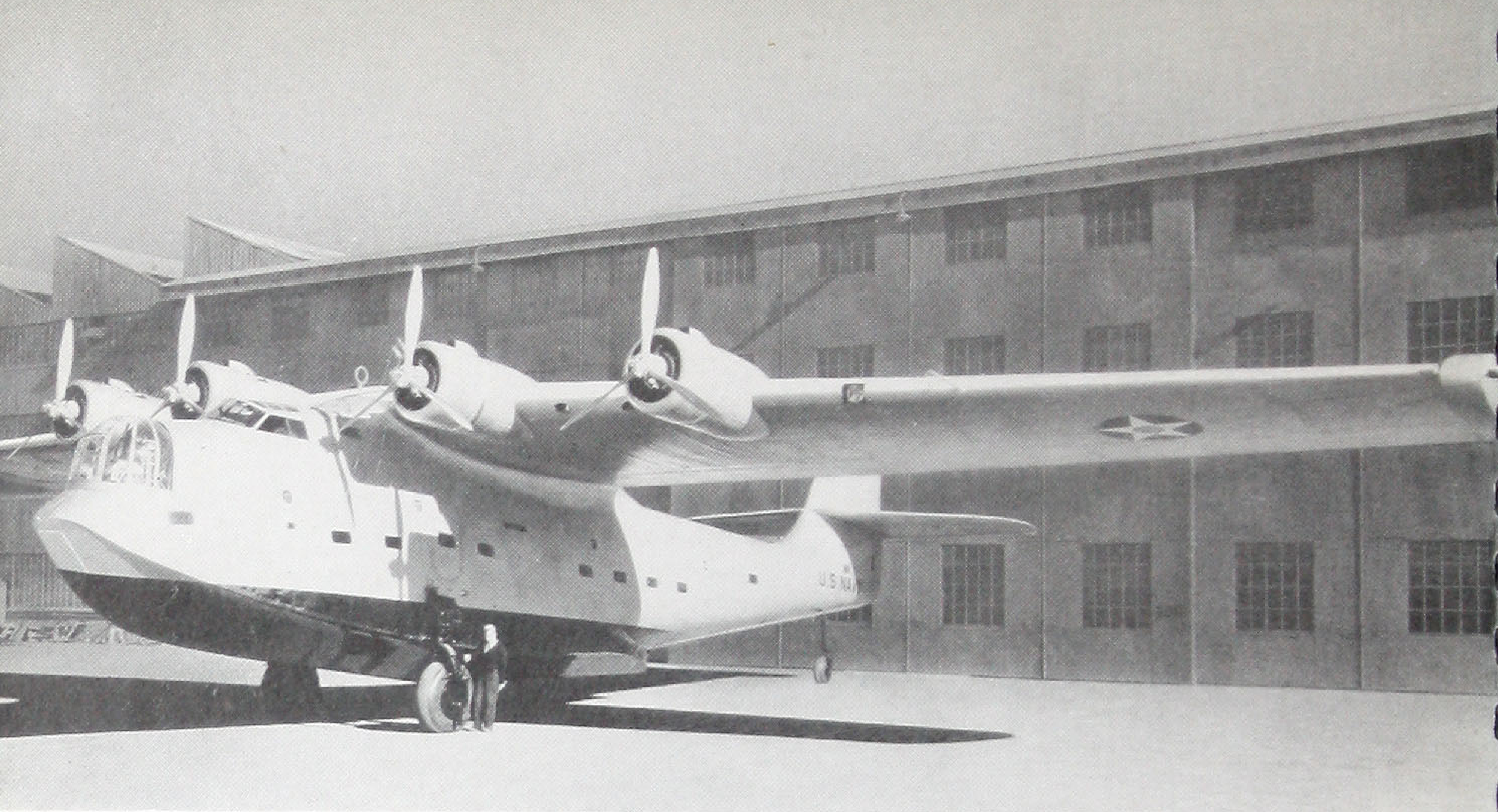
THE USE of paint or lacquer finishes on aluminum may be found desirable or even necessary for certain applications. In some instances paint constitutes the most economical type of decoration which can be employed, while in other cases its use is desirable from the standpoint of protection, especially where severe conditions of exposure are encountered. The painting of aluminum follows the general technique used for the painting of other metals.

When a paint or lacquer coating is to be employed solely for decoration, very little special preparation is needed. The surface must of course be clean and free from grease if satisfactory adhesion is to be obtained. Often a thorough cleaning with solvent is sufficient. When painting is done for protection, however, greater precautions must be taken just as in the case of other metals. Adequate preparation of the surface is quite important, as is the selection of a satisfactory primer. Different alloys of aluminum behave somewhat differently with respect to their ability to hold paint, but in all cases aluminum alloys are easier to protect with paint than are most other metals.

EFFECT OF ALLOY COMPOSITION

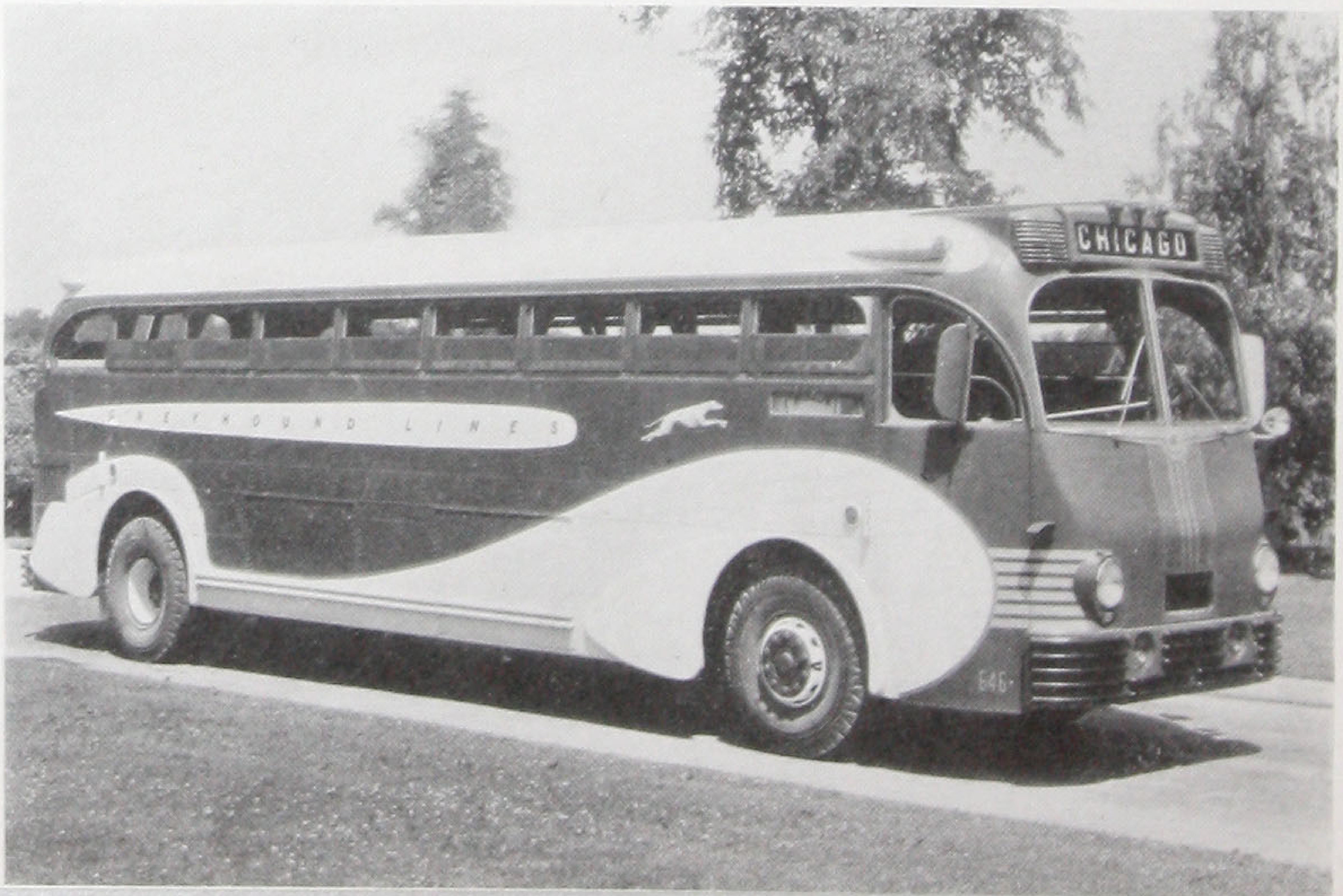
The alloys 2S, 3S, 4S, 52S and 53S have been found to show somewhat better paint adhesion than such alloys as 17S, 24S, 25S and 51S. Alclad 17S and Alclad 24S behave in much the same manner as 2S, doubtless because of the pure aluminum layer at the surface of the metal.

Most of the painting which is done for protective purposes is applied on the heat-treatable alloys. If proper attention is given to surface preparation and the use of an inhibitive primer, no difficulty in securing adequate protection should be encountered. Tests have shown that, even where a relatively poor surface preparation is employed, good results may be secured.



Serviceable finishes offering beauty and high resistance to corrosion are important in certain types of aircraft. It is common practice to give each part an anodic oxide coating followed by a coat of zinc-chromate primer before assembly; aluminum paint may be used as a top coat.

A unique and efficient painting system is employed in the finishing of Greyhound buses. Each part to be painted is suspended on a conveyor, sprayed with a chemical cleaner, rinsed, neutralized and dried by heat. A pigmented primer containing zinc chromate is then sprayed on, dried and baked. The complete assembly is finished with a surfacer and enamel or lacquer in accordance with automotive practice.



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SURFACE PREPARATION

There are many methods available for preparing an aluminum surface for painting. Surface roughening by sandblasting or scratchbrushing, although sometimes employed, is ordinarily not necessary and oftentimes is undesirable, particularly in the case of thin sheet sections. Surface roughening tends to impair the natural oxide film which is always present on aluminum and this renders the metal more susceptible to corrosion when moisture penetrates the paint coating. Except under very special conditions, therefore, surface roughening, particularly sandblasting, is not recommended.

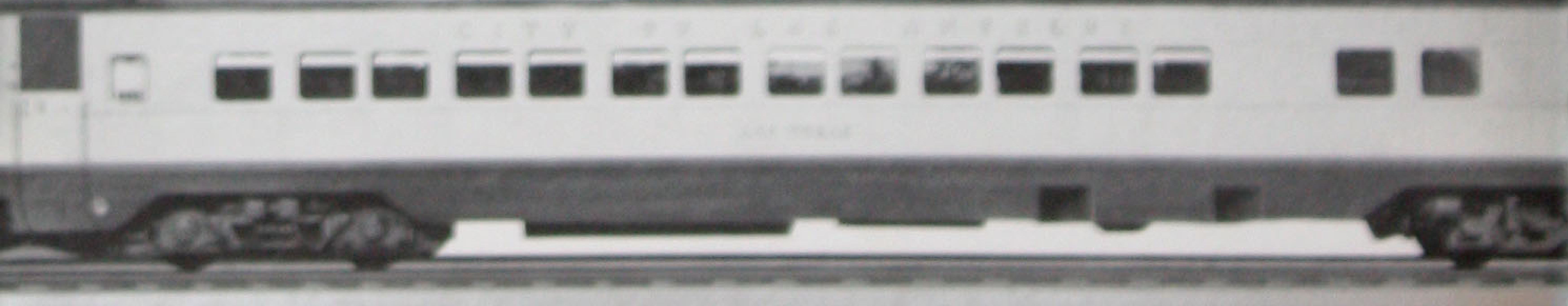
The simplest form of surface preparation is solvent cleaning. This can be accomplished by washing with cloths saturated with solvent, or by actual immersion in the solvent, followed by wiping with clean cloths. In either case it is difficult, on a commercial scale, to secure an absolutely clean surface in this manner since a thin film of grease usually remains on the surface as the solvent evaporates. In certain cases, this film may be removed by heating. An improved form of solvent cleaning is that of solvent vapor degreasing, which has proved entirely adequate for many applications. This overcomes many of the objectionable features of ordinary solvent cleaning, but mere cleaning is not sufficient for the more severe conditions of exposure.

A number of chemical treatments have appeared on the market during the past few years. There are two general types—mild alkaline solutions of the sodium phosphate or sodium silicate type, and dilute acid solutions containing phosphoric acid. The alkaline solutions appear to clean the surface of the aluminum without seriously attacking it and are fairly effective in securing good paint adherence. The phosphoric acid solutions, which usually contain water, alcohol or another organic solvent, in addition to phosphoric acid, are much more effective. Apparently they form a thin layer of aluminum phosphate on the surface which is quite insoluble and which tends to protect the aluminum against corrosion. There is a variety of proprietary treatments of this type available on the market.

Alrok coatings, described in a previous section, are also finding increasing use as a base for paint. They are decidedly better than the use of the chemical treatments mentioned.

The best surface preparation for the painting of aluminum and its alloys is obtained by means of anodic coatings. Where the use of this method is practical, it is strongly recommended. The Alumilite finishes produce corrosion-resistant, adherent, impervious oxide films which constitute ideal bases for paint. Their effectiveness depends upon their passive and non reactive qualities. They have found extensive use in the aircraft industry where the protection of thin sections is imperative. Impregnation of the coating with a chromate solution is an added precaution against corrosion.

The surfaces of aluminum trains and truck bodies are prepared for painting so that the paint film will bond itself to the metal and give maximum protection and durability. Concealed surfaces and joints should be cleaned and primed with an iron-oxide paint containing zinc chromate, followed by a coat of aluminum paint.



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After cleaning or otherwise treating the surface, the metal should be thoroughly dried by exposure to air or by heating, before paint can be applied. The metal should receive a minimum amount of handling after cleaning. The selection of the proper surface preparation from the foregoing methods is determined by the metal to be painted, the character of the structure and the service conditions to which it will be exposed.

METHODS OF APPLICATION

The methods of applying paint finishes are not peculiar to aluminum. Brushing, dipping and spraying may be employed. In addition, application by roller coating is particularly advantageous, especially where the metal is to be subsequently formed into various shapes, as in the case of bottle caps. Manufacturing considerations will determine the selection of the best method of application.

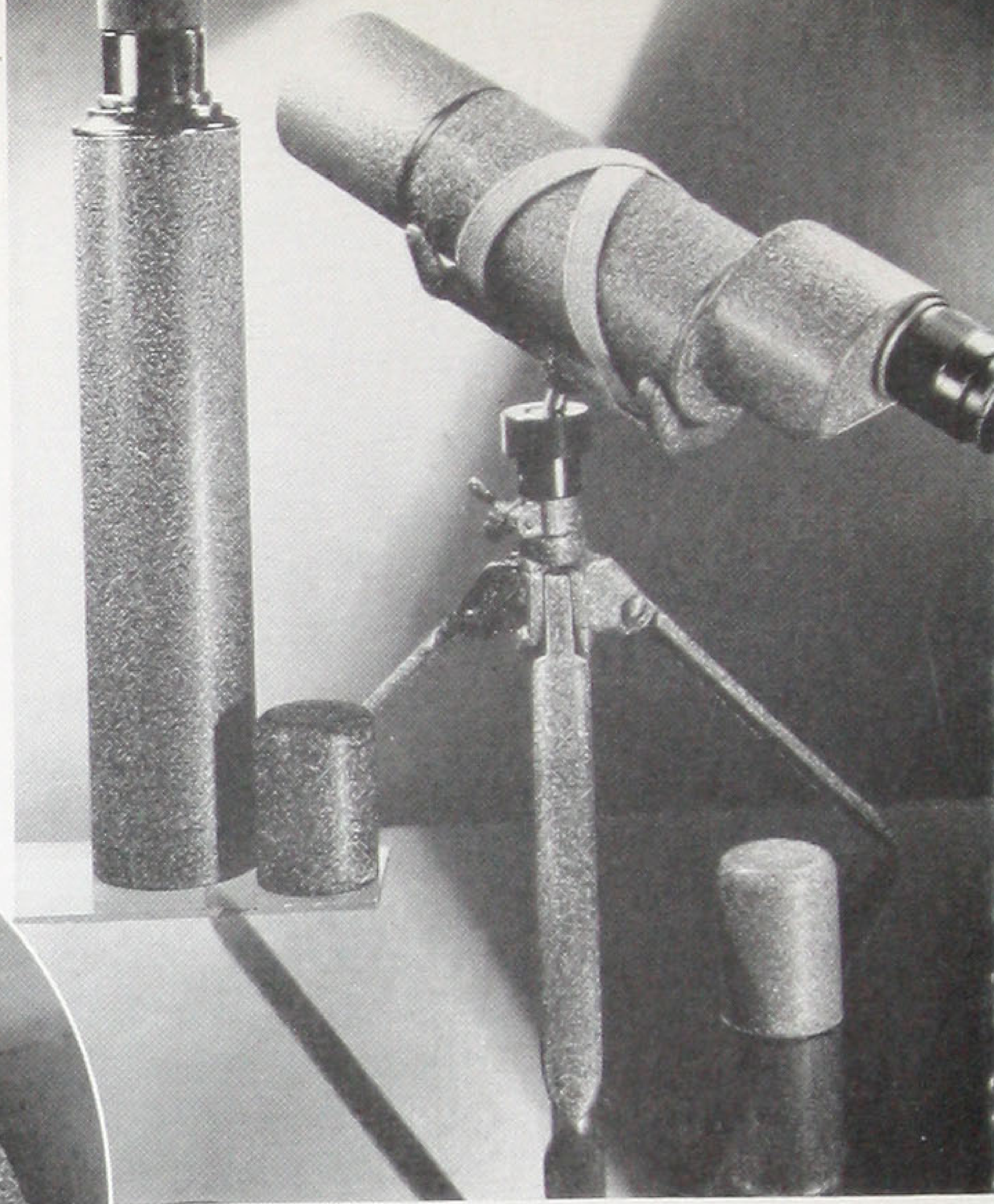
PRIMING PAINTS

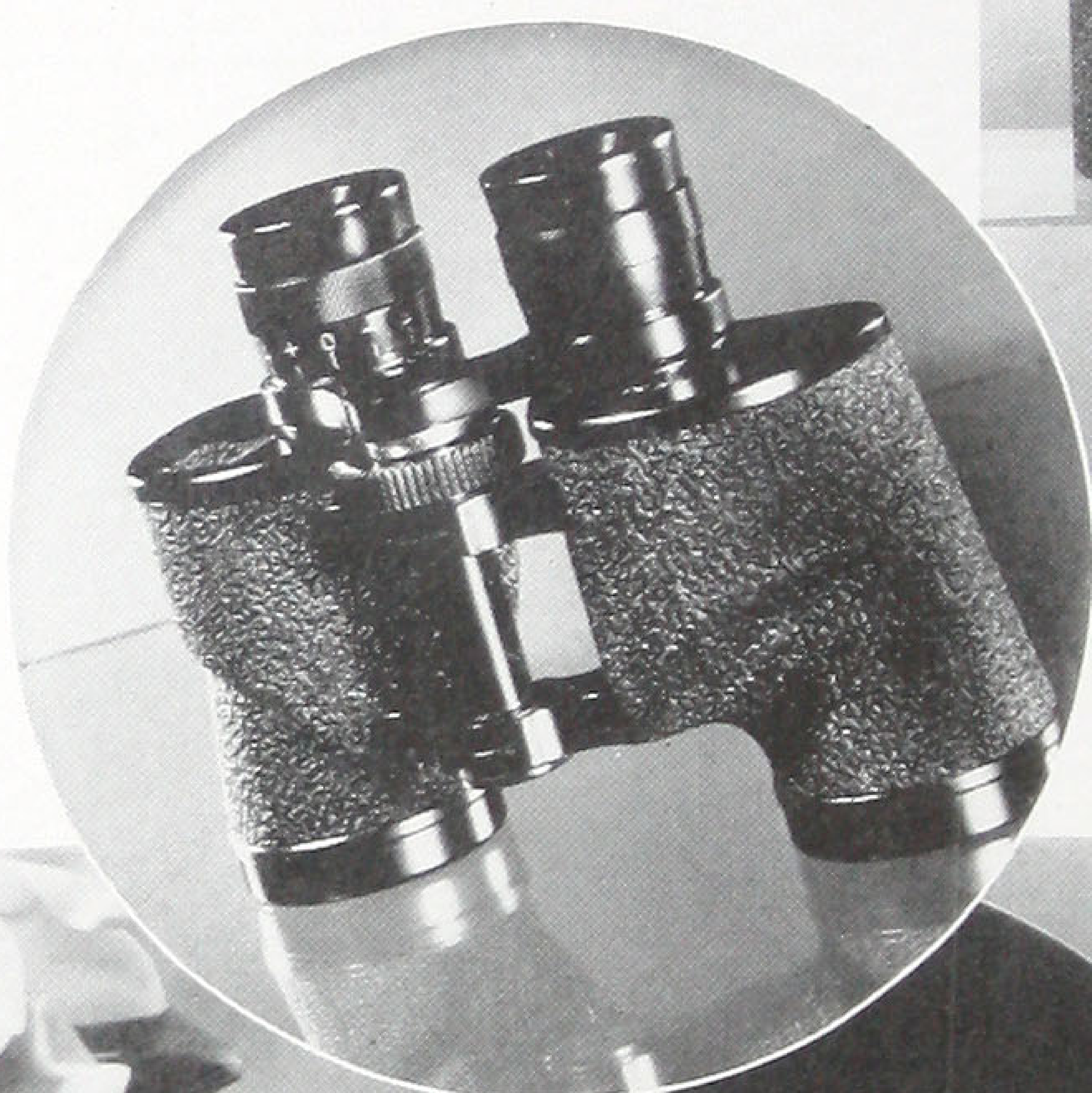
While it is not necessary to employ any special painting practice for applying decorative coatings to aluminum, a carefully selected painting system must be employed for protective coatings. The value of the system will depend to a large extent on the selection of the proper primer. The primer should have good resistance to moisture penetration to prevent surface reaction, should adhere well, form a good base for second coats, and should contain an inhibitive pigment.

Of the various primer pigments which have been tested for aluminum, zinc chromate alone appears to possess pronounced corrosion-inhibitive properties. A primer pigmented entirely with zinc chromate has been found, in most instances, to give the best results from the standpoint of protection. Such primers are commercially available.

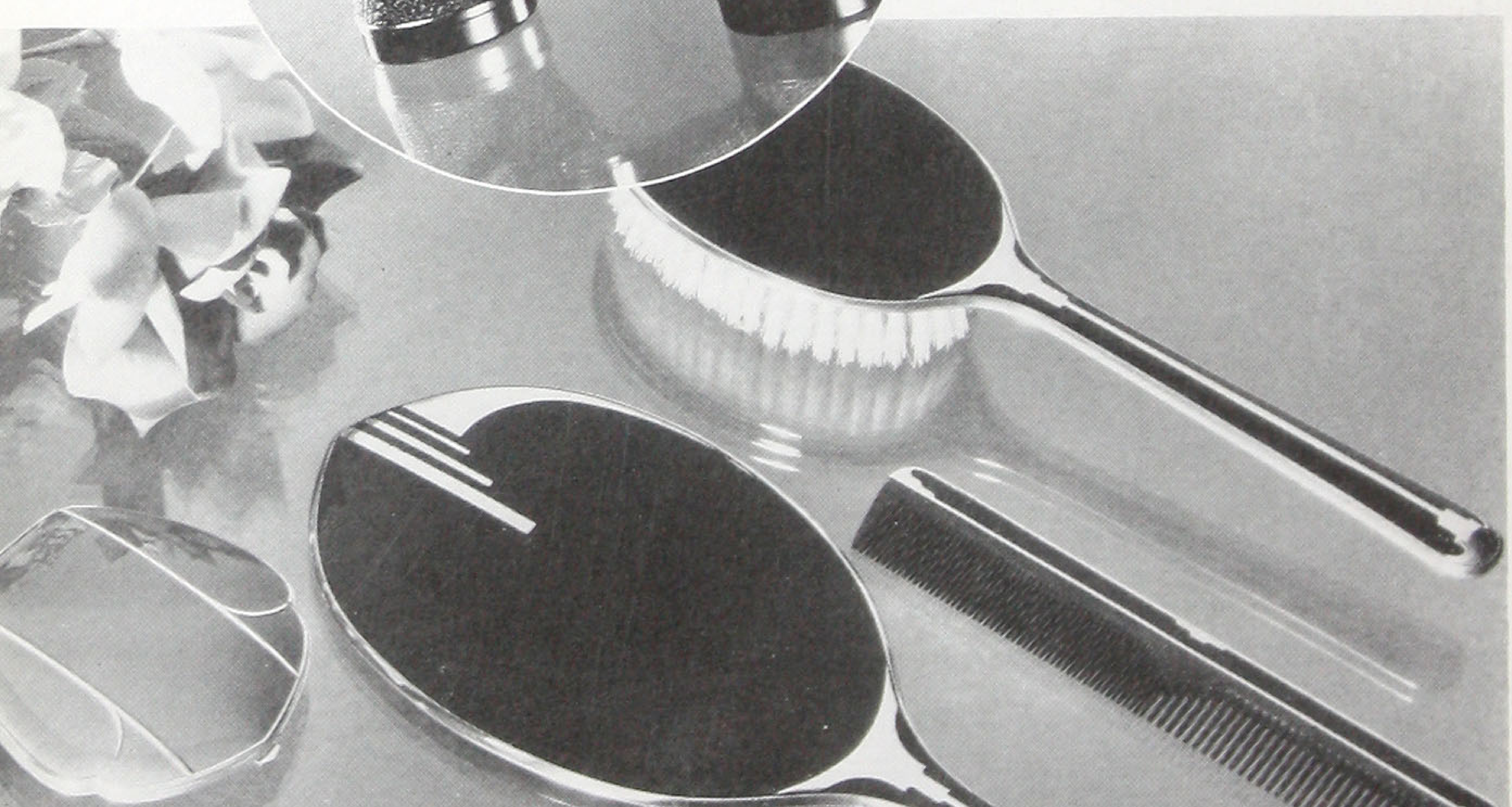
For less severe conditions of exposure, there is a large variety of primers which will doubtless prove satisfactory. In many cases, aluminum paint has been found to be a very satisfactory primer. It fulfills the requirement of high impermeability to

This spotoscope (right) and the binoculars (below) illustrate the use of pigmented coatings over an Alumilite finish. Alumilite finishes form excellent bases for paint and similar coatings on aluminum because of their inert or non-reactive characteristics.





A pleasing finish combination of enamel and polished aluminum is shown below.



★ ★ ★ FINISHES

moisture, good adhesion to the metal, and presents sufficient "tooth" for succeeding coats. Where finishing coats of lacquer are to be employed, a primer should be selected which is particularly designed for their use.

Proper selection of the vehicle is likewise necessary, since it is an important factor in determining the moistureproofing properties of the paint. With the aluminum primer, a long oil varnish vehicle or a synthetic resin varnish vehicle is suitable. Zinc chromate in a synthetic resin varnish base such as the alkyd resin or phenolic resin type is excellent.

FINISHING COATS

Once the primer is properly applied, almost any durable exterior paint or enamel may be employed for the finishing operation. These include oil base paints, long oil varnishes and enamels, synthetic resin finishes, and aluminum paint made either with a long oil varnish or with a synthetic resin varnish. Where the color of aluminum paint is satisfactory, it is especially recommended because of its properties of great opacity and high impermeability to moisture. The synthetic resin enamels have also been found to be effective as finishing coats because of their durability.

Bituminous paints may also be used for finishing aluminum, but, where they are used, a primer of the same material is recommended. If the black color of the bituminous paint is objectionable, it may be pigmented with aluminum powder to give an attractive finish.

Where extremely fast air-drying finishes are required, pyroxylin lacquers may be employed. These may be secured in any desired color, including aluminum. The aluminum-pigmented lacquers are, perhaps, the most durable since the tiny flakes of aluminum protect the nitrocellulose from the destructive action of sunlight. The most durable lacquers are those containing a certain amount of synthetic resin. In using a lacquer system, the primer must be carefully selected, as previously pointed out, so that it will be entirely compatible with the lacquer finishing

Collapsible tubes lithographed after fabrication.

Aluminum foil is attractively decorated by printing, lithographing and lacquering.

★ ★ ★ FINISHES

coats. The manufacturer of the lacquer is in a position to make recommendations for suitable primers.

CLEAR FINISHES

Transparent coatings may be employed to preserve the natural appearance of aluminum or to maintain a polished finish during outdoor exposure. They may be either lacquers or varnishes. For durability the lacquers must be of the type containing appreciable amounts of light-resisting resins such as alkyd, vinyl and methacrylate resins or containing cellulose esters such as cellulose acetobutyrate. Some varnishes made with glycerol-phthalate resins have given good service in such applications but most varnishes are of little use because of their tendency to turn yellow.

VITREOUS ENAMEL

Certain types of vitreous enamels may be applied to aluminum, but at present they have only limited application. This is because the relatively low melting point of aluminum (about 1200° F.) restricts the enamel to low melting compositions. The finely ground enamel is mixed with turpentine or water and brushed or sprayed in a uniform coating onto the aluminum, which is then heated to temperatures from 950° F. to 1050° F. Best results are obtained at the higher temperatures, but with greater risk of distortion of the metal. Most of the enamels which may be applied to aluminum are not entirely resistant to slow attack by water and hence are unsuited for many types of service.

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Form No. A.D. 117-A 5M-9-38

PRINTED IN U. S. A.
THE EDDY PRESS CORPORATION
PITTSBURGH, PA.